146

FORESTRY

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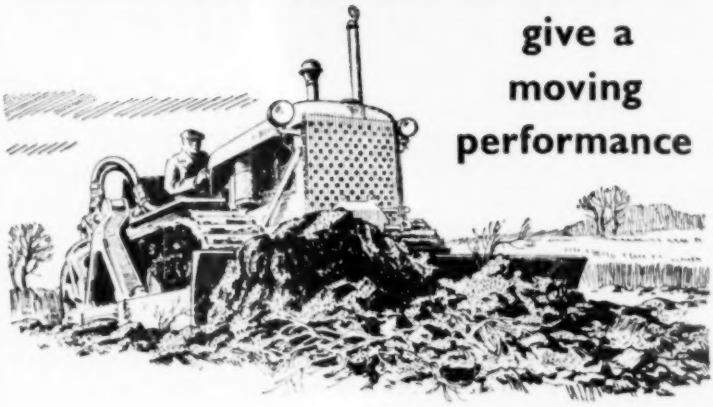

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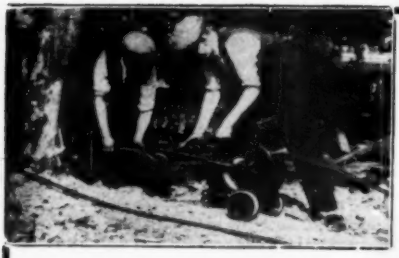

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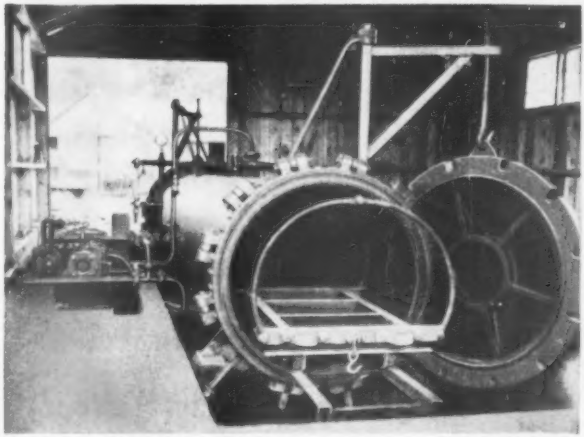

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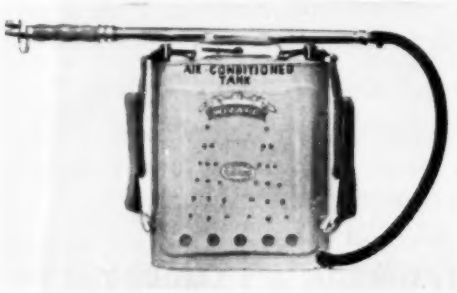

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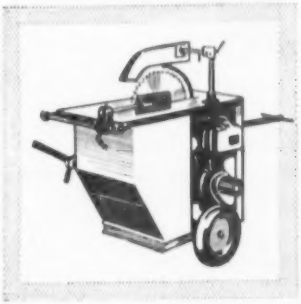

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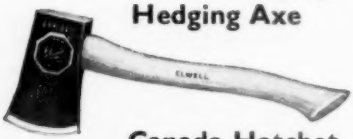

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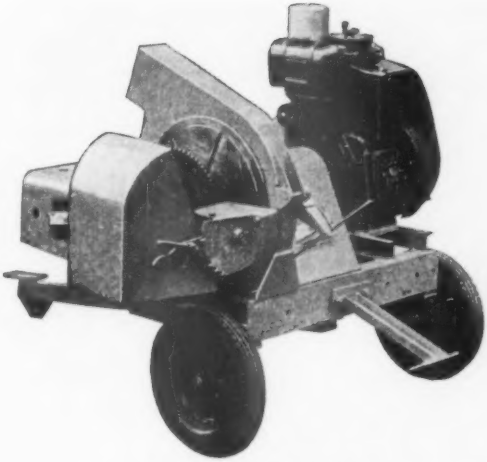

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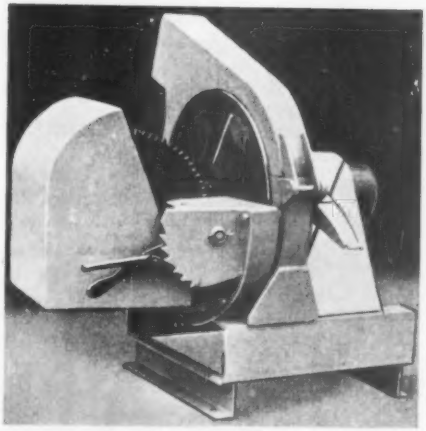

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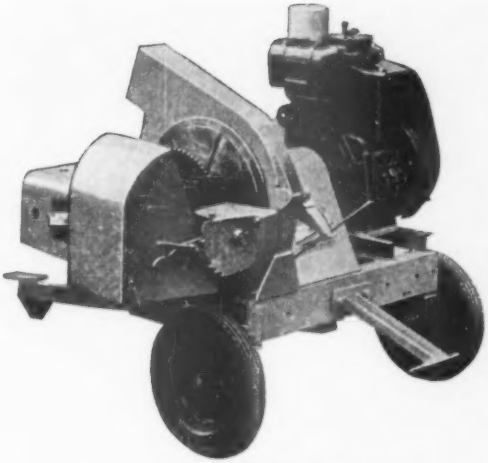

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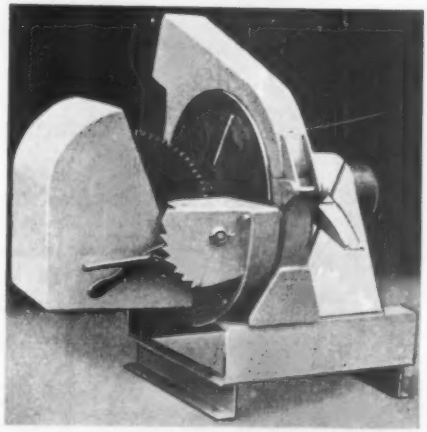

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(*Forestry Commission*)

SUMMARY

The need for the Forestry Commission to slow down its programme because of land shortage coincides with anxieties from the agricultural and social aspects about retrogression in large areas of upland grazings. The proper integration of forestry and agriculture in these marginal farming zones has been urged and this paper discusses the possible development of this theme. Land-use from either economic or social aspects must no longer be a matter for decision primarily by professional agriculturalists. There are wider implications wherein the forester must have equal say on land-use councils.

THE Forestry Commissioners in several of their recent Annual Reports have expressed anxiety at the inadequate rate of land acquisition. A gradual recession in the yearly planting programme has been necessitated and it is now impossible to achieve the rate of afforestation visualized in the White Paper on post-war forestry (Forestry Commissioners, 1943) which had been broadly accepted by the Government as fundamental for the achievement of a desirable national timber reserve.

Almost concurrently other anxieties have been expressed from the sociological and economic aspects in regard to the progressive agricultural retrogression occurring in several widely separated districts of upland grazing areas. The crofting conditions in Scotland (1954) and the uplands of mid-Wales (1955) have been the subjects of special reports and more recently the Natural Resources (Technical) Committee, appointed by the Lord President of the Council, under the Chairmanship of Professor Sir Solly Zuckerman, C.B., F.R.S., has issued a report (1957) in which the economics of forestry and agriculture on 'marginal' land are subjected to critical examination.

If the present paper has a predominantly Welsh bias the writer begs to be excused in that his experience is mainly limited to conditions within the Principality. It seems, however, that much of what follows may be widely applicable also to other upland grazing areas especially in the zones of high rainfall.

Forestry as a normal means of land-use is something quite alien to the upland farmer and as such it is naturally suspect. He sees, quite rightly, that forestry on the big scale can only result in a reduction of those hill lands which have hitherto been the unchallenged domain of his sheep. It brings about a radical change in the countryside and therefore it is unwelcome. And so it will remain unwelcome until facts can prove that it brings real benefits, be they economic or social or both, into the locality. Even then it will be welcomed by a different and largely by a new population and not by the ageing farmer who will still believe that as the

land had been sheep pasture for several generations, so it should continue for ever more.

It is necessary to face this fact. Forestry on the big scale is bound to be upsetting to the hill farmer even though it may clearly be to the benefit of the greater population of the district.

It is so obviously necessary in any country where hill farming predominates for the advancing forester to maintain good relationships with the farmer if healthy progress is to be achieved and thus has arisen a rather new school of thought calling for the sound *integration* of the farms with the forests to get the optimum use out of the soil and to retain the optimum amity between all those who work in muddy boots.

Perhaps for the first time in our generation farmer and forester have come, though maybe only theoretically, to agreement. There is scope for far more sound forestry in the hills and it can be achieved with little diminution in the stock-rearing capacity of the land by the planned adoption of this policy of *integration*.

How are we going to achieve it? Is it anything other than a new phrase, useful for platform oratory but impossible of implementation elsewhere than in a totalitarian State? What in fact does *integration* mean? There are two dangers, either of which would produce an ineffectual result. The forester may see in *integration* the possibility of a continuation of mass forestry, but with the exclusion of certain 'good' fields and the better farmsteadings which would be retained as small-holdings, unviable in themselves but providing useful dwellings for forest workers. Such a practice has in fact been adopted widely and systematically by the Forestry Commission ever since it began its operations. From the forest-management aspect it has been highly successful and the keen demand for reasonably situated smallholdings of this kind by the best types of country-bred woodmen is indicative that it has served a very definite social purpose. Where it has failed is in that it has not always made the best use of all the land, especially where good hill grazings above the tree-limit have been sterilized by removal of a necessary balance of more sheltered lowland, 'ffridd' or wintering. The Forestry Commission has been severely censured for having failed to appreciate this radical error in land-use; but it is only fair to say that the biggest developments of this system occurred in the years between the two world wars when hill farming was in the lowest of economic doldrums.

The pure sheep farmer, on the other hand, may see in *integration* the opportunity largely to preserve the *status quo* of hill farming as it is today, but improved by a good network of small shelterbelts fenced and maintained by, or at the expense of, a welfare State. That would undoubtedly be to the substantial benefit of the hill farms, but it would be totally incompetent to meet the needs of the country for a timber reserve, and it would have an entirely negligible effect in alleviating that grave social problem which is the steady drift of the best young folk from the more remote areas into urban employment or overseas.

It is interesting to find that the three reports referred to earlier, while all seeking to elucidate a broadly similar land problem, have each tackled it from a different aspect and therefore have presumably evolved rather different concep-

tions of the word *integration*. The Scottish crofting report is an unemployment report and it sees a definite salvation in forestry. The Welsh report is a sad story of degenerating farms in an area whence the population has been drifting for very many years. There is no unemployment because there are all too few people to employ. Forestry appears here as a means of using that land whence agriculture is receding (or has receded) and of providing a broader basis for a future social economy. The Zuckerman report tackles the problem more from basic economic aspects and considers the social implications only as a secondary matter. In Zuckerman's view there is an unanswerable case for more forestry purely on the national economic ground: the need for close integration with hill farming is largely put forward as a means to an end to get the adjustment made with the goodwill of the agriculturalists: that in itself is a perfectly valid point.

None of these reports fully considered the ultimate domestic implications of their recommendations: maybe the terms of reference of the respective committees were not sufficiently broad in concept. But if forestry and farming are to be made to flourish together on a sound basis in the marginal hill lands it is of tremendous importance to have a clear knowledge of the foundations upon which we shall be building our new citadel and of the final structure which we intend to create. Misunderstanding of the one or an indeterminate conception of the other could so easily lead to jerry-building of the most dangerous type.

Firstly, it is relevant to ponder the reasons why agricultural retrogression and consequent depopulation of the land began and why it is still continuing unchecked at a period of general high farming prosperity throughout the country. We have, for example, the figures quoted in the mid-Wales report where an area of 300,000 acres contained 2,186 farmsteads 50 years ago, but which today contains only 1,404 occupied farms and of these no less than 795 are considered to have a poor or doubtful prospect of continued habitation. A contemporary, independent survey of an area of some 38,000 acres in a remote part of the central Welsh uplands disclosed 29 unoccupied farms in various stages of ruin, 20 farms occupied but with clear signs of early pending abandonment, 19 farms with a fair prospect of continued occupation, and one tiny chapel (Plate II). In both of these examples an abnormally high proportion of the occupants were unmarried and well advanced in years.

In Wales the rapid development of the coal and tinplate industries in Glamorgan and Monmouthshire coincided closely with the decline of lead mining in the centre of the Principality and there was a rapid migration from mid to South Wales of miners, many of whom had themselves also been part-time farmers. Farmers and the sons and daughters of farmers followed, either to go into these industries or to go into the shops and other trades which followed the industrial boom. Meanwhile, the rise in the standard of education and the knowledge of a wider world as experienced by soldiers returning from the wars had sown the seed of discontent in the remote hills where living had always been hard and profits had never been high. The old way of life centred around the hearth with poetry, music, and handicrafts shared between a few (not very close) neighbours was ceasing to satisfy. The extremely primitive accommodation of many of the dwelling-houses

certainly had an important effect in accelerating the desire to move away. A very common standard of house comprised one earth-floored living-room and a diminutive 'parlour' downstairs with a ladder or steps leading up to one or two ill-lit attic bedrooms. Built of local shaley stone and mud-mortar, the life of these houses depended very much upon regularity of external limewashing to preserve the structure from the ravages of damp and frost. There is no doubt that many of them had been vacated, and the land sold to some more fortunate neighbouring farmer, simply because the home had begun to disintegrate beyond capacity for repair at reasonable cost and at a time when country masons had become both scarce and increasingly selective in the jobs which they would undertake. These tradesmen had also migrated in large numbers to the coal-mining valleys where much building was going on.

It is with this background of desire for good employment, yearning for reasonable social and educational amenities, and need for decent housing conditions that any resuscitation of the hill lands must be planned. Without intervention the result will be a continued migration of young people and a haphazard amalgamation of farms into larger and larger ranches. Sheep farming will flourish well so long as it continues to be adequately subsidized to pay for ever-rising costs of lowland wintering, but production per acre will continue to decline with the spread of *Molinia*, *Erica tetralix*, *Scirpus*, *Eriophorum*, &c., on the higher lands and of *Pteridium* on the better slopes. If it is obvious that the small marginal farms cannot be improved into good viable units, it is equally obvious from territorial survey that an ever more extensive type of hill sheep ranching under conditions of high rainfall and heavy soil is a sure way to destroy land fertility.

Economically, socially, or politically it is therefore of utmost importance that the management of these lands should be tackled on a considered basis: to let them drift will be to ensure their continued degeneration and with that the ultimate collapse of the social services, inadequate though they may be, and the several small townships whose already meagre livelihood depends upon them.

Though it is difficult to compare the human values of hill pastoral farming with forestry on similar land it is necessary to do so if we are to advance a new form of husbandry at the expense of the old one on social grounds, and there is in fact an increasing amount of reliable evidence available. On the agricultural side the mid-Wales report shows that 277,000 acres of farmlands, of which 195,000 acres were classed as rough grazings, employed 2,483 people including the owners or occupiers and also including 256 casual or part-time workers. Thus, even with the 82,000 acres of improved arable and grass-land the total rate of employment was only about one person to each hundred acres. Furthermore the report states that, 'if the present trend proceeds to its logical conclusion we anticipate that the numbers employed in agriculture will continue to fall for some years yet'. In fact, it is very evident that as amalgamation of the uneconomic small farms proceeds into a lesser number of large ones, which may be at least temporarily economic, so the diluted methods of husbandry will provide an equally diluted ratio of employment. We know of many large hill farms whereon the manpower employed is less than one to 500 acres. It might be argued that this does not present a true

picture in that much of the livestock is sent down to the lowlands for wintering or for finishing and there provides more employment. This is not a valid argument, however, because what we need to consider is the employment *in the hills*. Wintering in fact only too commonly takes place in localities where agricultural labour is already scarce.

Likewise in considering the employment value of forestry in similar country we should confine our attention to the manpower needed *in the forests* and ignore the additional industries of the saw-mills or other processing factories which may be situated many miles away. That it might be socially desirable to locate such industries close to the forests in the areas of depopulation is a matter of great local importance but hardly relevant to this paper.

Many assessments of the employment value of forestry have been made, but in Britain, where intensively managed and reasonably normal forests are virtually non-existent, no reliable data have hitherto been available. It is necessary to differentiate between the temporary employment value of a new forest in its formative stages and the ultimate employment value which will continue perpetually only when a condition of reasonable normality has been attained. According to the rate of formation and various early management factors the former can exceptionally be higher than the latter, and if we were to plan our domestic requirements on the higher figure we should only create awkward social problems for a future generation.

Even within this small island the final employment value of our forests will vary quite widely as between those yielding a high increment (e.g. spruce and Douglas fir) and the slower growing ones (e.g. Scots pine), between the easy flat areas and the mountainous ones, between the low and the high rainfall areas and very largely too according to the degree of processing of the felled timber in the forest or in the factory.

It is peculiar that none of the calculations recently published has been all-embracing; but as, for this purpose, we wish to assess the full social value of the forest in a given area we must obviously include every class of local forest employment, whether it be on the direct pay-roll of the forest owner or whether it be engaged by contractors or timber merchants.

The forests of North-west Germany (the British occupation zone of 1945–9), though not fully normal in age distribution, have been under systematic management for a very long time. They include a high proportion of easy flat land, but the quoted increment of 43 hoppus feet per acre per annum is probably a substantial under-estimate. Ryle (1948) gives an employment rate of only about one person per 100 acres, but as this excludes the manpower employed by timber merchants who habitually do most of the woodland conversion, extraction, and haulage and also excludes forest nursery workers, it would seem that a true figure would be not less than one person for every 65 or 70 acres. Hiley (1954) has secured some actual data for privately owned British woodlands, but as these contain large areas of unproductive and unmanaged forest land he rightly places little value in them. For properly stocked forests of softwoods he calculates figures ranging from one man per 100 acres for quality III Scots pine (with M.A.I. of 86 hoppus feet

per acre) up to one man per 35 acres for quality I Douglas fir (M.A.I. of 250 hoppus feet). Unfortunately he excludes from his calculations all personnel engaged on extraction, transport, and woodland processing (and probably local supervision).

At Thetford Chase in East Anglia, Backhouse (1957) quotes an employment figure of one man per 101 acres where nearly 5,000 acres of pines are being thinned each year in a young forest of 36,000 acres. The thinning is based on a 4-year cycle and some 45 per cent. of the area comprises immature crops not yet ripe for thinning, but largely in an extensive 'care and maintenance' stage which needs little labour. His figure is inclusive of internal transport and processing, but it excludes both local supervision and the very small amount of work done by contractors. It is evident that the manpower per acre will rise as further young stands attain the thinning stage and by the time that near-normality is reached so that the whole of the annual increment, in fellings as well as in thinnings, is cut each year, we could anticipate an employment figure not widely differing from the German one. Thetford Chase is, of course, an exceptionally easy forest for working: it has no roading or extraction problems, no mud, and a very dry climate.

The global figures provided by the Forestry Commissioners in their last published Annual Report (1955) of course refer to many forests wholly or largely in the formative stages and only a few whereon building-up has been finished. It is, however, interesting to find that *direct* employment, including local supervision, amounts to one person per 70 acres of the forested land. No figures are quoted in respect of the additional labour provided in the woods by contractors and timber merchants, but this is now attaining substantial proportions and a *total* employment of one person per 65 acres would be a fair estimate.

Concurrently in Wales, where the forest areas are situated predominantly in mountainous country and where rainfall is high, the figure of *direct* employment is one person per 54 acres and of *total* employment about one person per 49 acres.

The marginal hill lands about which this paper is specifically concerned are largely situated in the wetter side of Britain. They are gravely under-developed and will provide difficult problems of roading and extraction. Their productivity range is very wide. The more intractible heights and impervious upper slopes, consolidated by generations of sheep trampling, may not surpass quality IV Sitka spruce (M.A.I. of 166 hoppus feet); though even here there is plenty of evidence arising to show that these slow-starting crops improve steadily after they attain thicket stage. Very large areas on the other hand are of highly productive types where at least quality II Sitka (M.A.I. of 233 hoppus feet) will be produced. It would be pessimistic to estimate an ultimate yield of less than 150 hoppus feet per acre per annum from a range of various species. On the basis of the figures quoted above these hill lands, under intensive forestry, will certainly provide an ultimate permanent employment for about one person per 50 acres and it would be prudent so to arrange the rate of build-up that, in relation to the areas of land seen to be available in advance of each year's planting in any district, this number is never greatly exceeded on a long-term programme of steady expansion.

From a rate of agricultural employment at present declining *below* one person per 100 acres the expansion of forestry may therefore be expected to need, acre

FIG. 1. Roading will often be difficult. The Minister of Agriculture (right) inspecting a new forest road under construction

FIGS. 2 and 3. A countryside of many primitive and derelict farmsteads and one tiny chapel shown in the lower picture. The congregation houses its horses and sheepdogs during the service in a stable attached to the building

PLATE II

for acre, a doubled working population. Furthermore, such an increased population, consisting of active woodmen, must be expected to be generally young and more virile so that there will undoubtedly be a significant rise in the marriage- and birth-rates with resultant new demands on social and educational services.

It would be wrong to assume that a steady influx of new blood into these depopulated areas will at once produce an acute housing problem: fortunately experience has shown that there is normally some lag between the creation of the new block of employment by forestry and the appearance of an urgent demand for additional housing. On the other hand there is a temptation to evade the housing difficulty by transporting men daily from distant townships, where they frequently live in subsidized houses, merely to delay the need to build new subsidized houses closer to the forest. This is clearly not economic in direct cost and it fails to give the forest employees that footing in the countryside which is so essential if we are to retain the best types of men. Bearing in mind the general deplorable housing conditions in the more remote hill districts, we must, however, anticipate a need to provide new dwellings for the majority of the forest employees within a generation. This becomes an important step in the process of *integration*, because there are obvious advantages in every way in providing the new houses as extensions (or replacements) in the existing villages and small towns nearest to the forest areas. Thus the woodman and his family in their hours of relaxation will be rubbing shoulders with the farmer and farm worker, the village handyman, and the tradesmen and their families: they will no longer be aliens.

It is an unfortunate fact that at the time of writing, the restrictions on capital developments should result in a virtual stoppage of rural house building in all the poorer districts because no local housing authority in a lowly rated area—and these marginal hill areas are essentially lowly rated—can afford to erect modern dwellings at a rental value which the rural artisan can afford to pay. This position necessitates the continued recruitment of remote dwellers, costly daily transport, and lower output of work. An opportunity to begin the repopulation of the under-manned areas is unavoidably being delayed.

With this domestic background it becomes possible to make a realistic forecast of the manner in which the ideal farm-forest integration should develop. There is at last a slight move towards the views expressed by E. H. F. Swain (1947) of New South Wales when he addressed the Fifth British Empire Forestry Conference on the matter of land utilization as long ago as 1947. 'It seems to me that we have conceded paramountcy to agriculture in relation to forestry as a means of land-use which exceeds its merits.' A realization has *begun* to become apparent amongst professional agriculturalists that sound land-use does not lie solely within their province, but that forestry must have an equally important place for both social and economic reasons and thus that the forester must have an equal status on their councils.

In these hill districts there are large areas whence the people have already migrated to such an extent that agricultural values have dropped to a low level. Here forestry is bound to replace sheep ranching as the major, or perhaps even almost the sole industry. The problem of integration will be confined to an

adjustment so designed that the unplantable summer grazings above the economic tree zone can be fully utilized. This will mean that certain of the middle and lower territory, while itself being more suitable for timber production than for mutton production, will have to be retained for pasturage so as to provide feeding ground in the early spring, the late autumn, and to some extent throughout the winter months. Whether such an economy can be sustained for many years in the absence of resident shepherds is a matter which only time will tell. There is perhaps more than a possibility that some of them will go out of food production in favour of further extended forestry in due course. If so the change, even though it may leave the highest lands unused will not necessarily be uneconomic. However, if such a drift can be prevented for 20 years or so the improvements to the middle slopes or ffridd land created by the shelter of the adjacent plantations—and herein careful initial layout will be of tremendous importance—may well be so outstanding that their stock-carrying capacity, especially in hard weather, will be substantially improved. So long as mutton and wool can remain alive as an industry in these remote hills it is important that it should become an increasingly self-contained one because the extension of milk, beef, and arable husbandry in the lowlands has already caused a serious shortage of wintering and a steep rise in prices for tacking of hill sheep.

Far the most difficult problems of farm-forest integration will arise in the rather less marginal hill areas, in districts where transport and other social services are more adequate, where housing standards are often better, and where a higher ratio of the acreage, often because of better management rather than due to intrinsic conditions, is agriculturally more fertile. Here obviously a more mixed type of husbandry is practised, though sheep continue to be a mainstay. Farming, with hill subsidies, is relatively prosperous, but none the less a great many of the farms contain substantial parts which are of very low food-producing value and which would in the long run serve both the occupier and the nation more profitably under timber. But today's occupier sees little benefit in adopting a scheme of mosaic afforestation for which he personally will seldom reap a direct reward; he sees little advantage in disposing of parts of his farm to the Forestry Commission unless they can offer him something appreciably in excess of the normal market price. Though he may agree that the portions concerned are his least valuable food-producing areas he will seldom admit that they are merely of basic prairie value. In so far as they may commonly form inliers or islands within his boundary he has a very real justification for maintaining that they should carry an enhanced value. Unfortunately too there are few of these hill farmers who are greatly interested in creating an improved shelter which will hardly become effective until 15 or 20 years have elapsed.

Always bearing in mind that one of the important reasons for embarking upon this integration policy is to secure and to retain the goodwill of the farmer, and therefore at once ruling out altogether any ideas of authoritarian compulsory processes, we must endeavour to translate the policy from the realms of woolly idealism to something which can be put into practice.

First of all, the policy having been accepted, it is paramount that the two bodies

concerned in carrying out that policy—agriculturalist and forester—must have equal weight in all discussions on optimum land-use. No longer can consideration be based merely on food production versus *loss of food production*. The real decision can only be reached after the relative claims of food, timber, population, and economics, not for a year or two but on a long-term perspective, have been weighed dispassionately. No longer must agriculture hold the fort because certain types of land are *capable* of being improved for food purposes: the criterion must be whether certain types of land are in fact being properly used *now*.

The remote hill-ranch type and the very sub-standard marginal farm with its house and buildings falling into ruins do not cause a real problem because the advent of the Forestry Commission has opened up a new market where previously the only opportunity to sell occurred when a close neighbour happened to be a buyer. The fact that these properties are steadily coming into the management of the Commission will ensure the attainment of sound planning, though to carry it out on the best ultimate lines means that there should often be delays until several adjacent properties fall in hand, thus enabling proper amalgamations of farm lands (with the best of the buildings) to be correlated with the afforestation plan. Sound integration cannot be organized on the basis of each individual farm as it exists today. Disposal, whether by sale or permanent letting of the agricultural portions, should thus never be rushed until carefully planned amalgamations can be effected. The forest-farm integration-amalgamation policy is totally incompatible with any policy for hurried disposal of 'surplus' farm properties in marginal districts.

We see, therefore, that in the (agriculturally) poorest districts development of the integration policy will inevitably be secured by a continued process of land acquisition by the Forestry Commission, because a high proportion of the area will advisedly be converted from mutton to timber production and because State forestry is a normal and accepted mode of rural development. But the same process, if adopted in the less marginal farm uplands, would involve the investment of large sums of public money in the purchase of improved agricultural land and fixed equipment. On the threatened break-up of large estates this might often be a wise investment: it would enable well-considered farm amalgamations to be operated concurrently with the creation of integrated forest schemes. It would, in fact, enable the whole estate, which had probably developed along a certain pattern many generations ago, to be redesigned in better accord with today's principles of efficient land-use. The subsequent ownership disposal of the final agricultural residues is a political matter about which we need not concern ourselves here.

In Wales, however, there are few such large estates and development along similar lines could only be achieved slowly and spasmodically by a process of individual farm purchases, waiting until suitable 'amalgamation-integration' blocks had been built up and then treating them in a like manner. Adjacent properties might come on the market at remote intervals of time; meanwhile costs of interim management would often be uneconomic. It is a policy, in fact, which might occasionally be valuable, especially in the vicinity of existing State

properties, but could hardly be of general application. It might, in fact, be psychologically as disastrous as it would be economically unsound.

We come then to individual and voluntary effort of each owner or occupier to place under forest crops all those parts of his farm which are suitable for timber production but of low value for food. He has the opportunity to invest his own capital in the enterprise and carry out the work by his own direct effort or through the aegis of an agent or a co-operative forestry society. Alternatively he can dispose of the land to the Forestry Commission. We know, however, that either is at present a pipe dream: the work, under present conditions of nurtured agricultural economics, will proceed slowly and painfully only to the extent that the unflagging efforts of a tiny band of forest enthusiasts is able to counter the current apathy of local opinion. We have already postulated above that future decisions on land-use should be reached in joint consultation between farmer and forester. Today we see a very different picture where farmers are a consolidated body doing magnificent work in raising the standard of agricultural production, but largely disinterested in their residues of land which are wastes.

Increase in forestry on these less marginal hill farms will, we believe, only be accelerated by a really widespread educational campaign which must reach the owner or occupier not merely from the mouth, maybe a trifle biased, of the forester but from a great variety of sources.

First and foremost there is needed a clear declaration and explanation of policy: this does not necessitate any change in present policies, but involves a welding together of those policies which in isolation can so easily *appear* to be inimical to one another. In fact integration in the field will never be achieved without integration of policies.

There is today a very direct contact between farmers and the day-to-day administration of agricultural policy through the County Agricultural Executive Committees and their technical lands officers. From a slightly different angle the farmers' unions and co-operative marketing organizations are minutely observant of current farm policies. From the direct educational and advisory viewpoint the agricultural advisory officers and the County and other Farm Institutes are in close touch with all farmers and able to help them and their sons with their technical problems. But all these bodies are strangely ignorant of the forest policy of the country and therefore sadly incompetent to guide local effort on the lines of full land-use or of a bolder forest-farm integration policy. In fact, being heavily burdened with the advancement of the food-production policies all these bodies tend very naturally to look upon the use of our soil for any other product as being retrograde and even improper. Here then must education begin and it will need to be sponsored and encouraged from the highest policy-making levels. Here, we believe, is the only way by which the advancement of forestry in sound micro-integration, geographically and economically, with agriculture can begin. Once the beginning is made, and it matters not whether it is in the farmers' derelict woodland or on his derelict bare land, it will certainly gain speed to affect them both. But an adequate beginning cannot be made by foresters working alone. The forester will need something much more forceful than the slightly suspicious

benignity of the professional agriculturalist if the latter's own ideal of farm-forest integration is to succeed. It must be an all-out fully integrated campaign.

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FOREST MACHINERY EXHIBITION

THE Forestry Commission is to hold an exhibition of forest machinery at Bramshill, on the southern edge of Blackbushe Airport, near Camberley, Surrey, on Wednesday and Thursday, 28th and 29th May. The exhibition will be on the lines of that organized by the Gascoyne Cecil Estates at Hatfield in 1956. The date has been arranged to coincide with the visit to Great Britain of the Food and Agricultural Organization (Economic Commission for Europe) Working Party on Afforestation and Reforestation.

Machinery on view will include tractors suitable for forest work, power saws, timber carriages, vehicle loaders, drain diggers, bark peelers, ploughs, forest nursery machinery, planters, winches, saw benches for conversion of timber, and other types of machinery that can be used in the forest. The interests of private woodland owners are being kept in mind in presenting this exhibition, and it is hoped that it will be possible for some of the machines to be shown in operation.

Approach to the exhibition is by the main London–Basingstoke road. There will be no charge for admission but a car-parking fee will be charged in organized car parks and visitor's cars will not be admitted to the exhibition ground itself. The exhibition will be open each day from 10.30 a.m. to 5 p.m.

Entries for machinery closed on 3rd April.

COLLEGE DIPLOMA IN FORESTRY

A COURSE of five terms and three practical courses of three weeks each is provided by the Edinburgh and East of Scotland College of Agriculture leading to the College Diploma in Forestry. The course is designed for those desiring a career as forest foremen, managers or foresters on private estates, private forests, or elsewhere, for foresters already in training, or for anyone desirous of studying the principles on which practical forestry enterprises are based.

Applicants must be at least seventeen years of age and have completed at least four years of secondary education or the equivalent. A satisfactory training in chemistry, physics, and mathematics is desirable. Before entering upon the course, a practical knowledge of forestry must have been obtained by working in an approved forestry scheme in the British Isles covering a complete year of forest operations. Special arrangements may be made for men over twenty who have experience in the practice of forestry provided they can show that they have sufficient preliminary education to enable them to benefit from the course.

Applications for admission to the course must be made on a special form to be obtained from the College Secretary, 13 George Square, Edinburgh, 8, before 31st May in the year in which studies are to be commenced. The 1958 session will open on the 7th of October.

NATIONAL DIPLOMA IN FORESTRY

THE National Diploma in Forestry instituted in 1951 is awarded by the Central Forestry Examination Board of the United Kingdom. Members of the Board are appointed by the Royal Scottish Forestry Society and the Royal Forestry Society of England and Wales.

The Diploma may be awarded annually after an examination which is both written and oral. Candidates for the Diploma must be twenty-five years of age or over and must have had responsible practical experience for not less than three years after being awarded the forester's certificate of one of the constituent societies or of the Forestry Commission. For further information and for the rules and syllabus governing the examination, application should be made to the Secretary to the Board at 7 Albyn Place, Edinburgh 2.

THE NUTRIENT CONTENT OF SCOTS AND CORSICAN PINES GROWING ON SAND DUNES

By T. W. WRIGHT and G. M. WILL

(*The Macaulay Institute for Soil Research, Aberdeen*)

SUMMARY

A study has been made of the amounts of N, P, K, Ca, Mg, and Na in the needles, branches, bark, and wood of three age classes of Scots and Corsican pine (*Pinus silvestris* L. and *P. nigra* var. *calabrica* Schneid) growing on sand dunes at Culbin Forest, Morayshire.

Of the seasonal variations observed, the most significant was a rise in the N content of the bark in the autumn, especially in young trees.

Dominant trees have lower levels of P, K, and Mg in the needles, branches, and bark than suppressed trees.

Dead bark accumulation is much more uniform on Corsican pine than on Scots and the nutrient content of dead bark is small.

Heartwood development is greater in Scots pine than in Corsican. In the heartwood of both species P and K contents are very low, but Ca, Mg, and Na accumulate. In the sapwood zone immediately surrounding the heartwood, high levels of all nutrients are found.

The total amount of nutrients held in the crop has been calculated on a per acre basis for the three age classes of both species. At 48 years this value is still rising in Corsican pine, but at 64 years the total content of N, P, and K in Scots pine is beginning to fall, although the Ca content is continuing to rise due to heartwood formation.

The bark and stem contain between one-third and one-half of the total nutrients in a tree, depending on age. Barking of stems before removal reduces nutrient losses from the site, but appreciable quantities are still removed in the wood.

IN a recent study of the uptake of nutrients by trees in relation to the available nutrient reserves of the soil, Rennie (1955) has drawn attention to the very considerable quantities of nutrients immobilized in the crop, and has questioned the ability of our poorer soils to supply, over prolonged periods, the nutrients required to maintain continuous timber production. To enable estimates to be made of the total nutrient uptake by forests and of the proportion of nutrients removed permanently from the site by exploitation, it is necessary to ascertain the total nutrient content of individual trees, the distribution of nutrients between the various organs, and the variations between different species and age classes. Rennie based his study on the work of German and French authors carried out towards the end of the nineteenth century, this being virtually the only published work on the nutrient content of whole trees and of their component parts.

The object of the present paper was to obtain fresh information on the nutrient contents of Scots and Corsican pine (*Pinus silvestris* L. and *P. nigra* var. *calabrica* Schneid.) growing on poor soils under British climatic conditions. Culbin Forest, an extensive area of aeolian sand dunes bordering the south coast of the Moray Firth, was chosen as a suitable experimental area, since it contains a range of age

classes of both species growing together, and previous investigations (Ovington, 1950; Wright, 1955, 1956) have shown that the soil has an inherently low nutrient content which has already been appreciably reduced by the growth of the crop.

LAYOUT OF SAMPLE PLOTS

The topography of the Culbin dunes has been described in detail by Steers (1937). In order to minimize the effects of soil variation, sample plots were confined as far as possible to the high dunes, but the sample plots in the two younger stands of Scots pine had to be sited on rather lower ground, since experience has

TABLE I. *Crop measurements in the sample plots*

	No. of trees per acre	*Mean quarter girth (in.)*	*Mean height (ft.)*	*Volume* (cu. ft./acre)*
Plot A	2,100	2	15	360
Plot B	1,460	3	28	930
Plot C	450	6	44½	2,100
Plot D	2,100	2½	18	710
Plot E	860	4½	39	1,970
Plot F	330	7	54	2,240

* Hoppus measure.

shown that this species is not suitable for the drier dunes and its planting has latterly been restricted. The sand in these plots, however, has a similar low nutrient content, and differs from that of the high dunes mainly in its rather better moisture status and the longer period for which it has remained stable.

Sample plots were laid out in the following compartments:

Plot A. Compt. 10. Corsican pine, aged 18 years.
Plot B. Compt. 17. Corsican pine, aged 28 years.
Plot C. Compt. 176. Corsican pine, aged approximately 48 years.
Plot D. Compt. 17. Scots pine, aged 18 years.
Plot E. Compt. 68. Scots pine, aged 28 years.
Plot F. Compt. 173. Scots pine, aged approximately 64 years.

Plots B, C, and F were $\frac{1}{10}$ acre in area and plots A, D, and E were $\frac{1}{20}$ acre. Total crop volumes were calculated from measurements made in each plot. These are given in Table I.

METHODS AND DATES OF SAMPLING

Since the investigation was mainly concerned with possible nutrient losses caused by utilization, roots were not sampled.

Seasonal variations in the nutrient composition of conifer needles are already well known (e.g. Leyton, 1948). In order to investigate possible seasonal differences in the nutrient content of other organs and of the whole tree, samples were taken at three different times. In June 1956 one tree of mean quarter girth was felled in each plot and a similar mean tree was taken in December 1956. To enable a

comparison to be made between different sized trees of the same species, two further trees, selected at random, were felled in each plot in September 1956.

After felling, the branches were cut off each tree and divided into two groups—those from the top of the crown and those from its base; to the latter group were added any dead branches on the lower stem. Depending on the volume of branch material present, either the whole of these groups or sub-samples were taken for analysis. The needles were stripped from each group of branches and divided into 1956 needles, 1955 needles, and older needles. Further subdivision of the needles was not made, as only small numbers of fourth-year needles were present and fifth-year needles were only found in a few cases. After oven-drying at 80° C. these branch and needle samples were weighed and the total dry weights per tree calculated.

Depending on the size of the trees, from two to four disks were cut from each stem. One disk was taken just above ground level and the others at intervals up the stem. The bark was stripped from each disk, its oven-dry weight determined, and this used, together with the surface area of the wood from which it had been stripped, to calculate the weight of bark per square inch of stem at the various heights. No differentiation was made between dead bark (cork) and living bark (phloem and cambium).

The volume of each disk of wood was measured before oven-drying. From these volumes and the oven-dry weights, density figures were calculated for converting volumes of green wood to oven-dry weights. Each disk was then divided into from two to five samples, depending on its diameter, by splitting off concentric zones having approximately equal volumes of wood in each zone. If heartwood (as indicated by its staining reaction with benzidene-sodium nitrite solution) was present, it was separated from the surrounding wood but not subdivided. The surface area of each zone in the disk was calculated.

METHODS OF ANALYSIS

After oven-drying, all samples were ground in a Wiley mill. The nitrogen content was determined by a semi-micro Kjeldahl technique using a selenium catalyst. After ashing at 450° C. and extracting the ash with 0·1N HCl, calcium, potassium, and sodium were determined by flame photometer (Ure, 1954) and magnesium by the spark method of Scott and Ure (1957). The phosphorus contents of the HCl extracts were determined colorimetrically (Hanson, 1950).

RESULTS AND DISCUSSION

1. *Differences due to age and position of sample*

In preference to reporting average values for the two species, the results from the trees felled in plots C and F in the late autumn are given to illustrate differences in nutrient content due to position, age, and species. These values, and the variations between them, are typical of those found in the other samples. The results are given in Tables II, III, and IV and Fig. 1 (*a*) and (*b*).

Needles. The nutrient contents and the weights of the three age groups of needles on a 48-year Corsican and a 64-year Scots pine are given in Table II.

TABLE II. *Weights and nutrient contents of needles*

	Crown position	Age	Dry weight (g.)	Percent. oven-dry sample					
				N	P	K	Ca	Mg	Na
Corsican pine	Top	1956	1,250	0·97	0·155	0·83	0·20	0·105	0·015
48 years		1955	1,060	0·89	0·120	0·81	0·35	0·095	0·015
		older	2,180	0·76	0·115	0·69	0·60	0·090	0·015
	Base	1956	310	0·94	0·135	0·77	0·10	0·085	0·015
		1955	330	0·87	0·105	0·64	0·20	0·080	0·015
		older	1,120	0·73	0·100	0·63	0·40	0·070	0·015
Scots pine	Top	1956	490	1·48	0·170	0·71	0·30	0·120	0·035
64 years		1955	510	1·42	0·150	0·61	0·70	0·135	0·065
		older	260	1·30	0·150	0·54	0·95	0·115	0·130
	Base	1956	650	1·20	0·145	0·70	0·25	0·090	0·035
		1955	1,050	1·22	0·135	0·61	0·60	0·115	0·070
		older	480	1·33	0·135	0·56	1·00	0·110	0·160

The rise in the Ca and Na contents in the needles of both species with age and the accompanying fall in N, P, and K are similar to those found in other conifers (White, 1954; Will, 1957). It may be noted that while Corsican needles have a higher K content, levels of all other nutrients are higher in Scots pine.

Branches. Weights and nutrient contents of the branches of the two trees are shown in Table III.

TABLE III. *Weights and nutrient contents of branches*

	Crown position	Dry weight (g.)	Percent. oven-dry sample					
			N	P	K	Ca	Mg	Na
Corsican pine	Top	2,720	0·37	0·050	0·36	0·45	0·095	0·015
48 years	Base	6,370	0·21	0·020	0·14	0·45	0·060	0·025
Scots pine	Top	2,740	0·49	0·060	0·34	0·30	0·080	0·030
64 years	Base	17,670	0·22	0·025	0·14	0·20	0·050	0·025

As might be expected, branches in the lower part of the crown, with their greater proportion of wood tissue, have lower contents of N, P, K, and Mg than those in the upper crown. Ca and Na do not follow this trend; as will be seen later, these two elements tend to accumulate in older wood.

Bark. There are appreciable differences between the two species both in the nutrient content of the bark and the way in which it is formed (Table IV).

Whereas in Corsican pine the dry weight of bark increases gradually from the top to the bottom of the stem (i.e. dead bark is steadily accumulating), in Scots the accumulation only occurs near the base of the tree. Living bark, being a transporting and actively growing zone, has a higher nutrient content than dead bark, so that in Corsican pine a gradual decrease in the nutrient content of the

total bark takes place down the stem, while in Scots there is an abrupt decrease at the base. In both species, however, there is an overall net increase in the nutrient content from top to bottom, since the increase in dry weight exceeds the decrease in nutrient content.

The high Ca values in the bark of Scots pine compared to other parts of the

TABLE IV. *Weights and nutrient contents of bark*

	Height of sample (*ft.*)	*Dry weight per sq. in.* (*g.*)	*Percent. oven-dry sample*					
			N	P	K	Ca	Mg	Na
Corsican pine	34	0·73	0·36	0·055	0·29	0·25	0·120	0·015
48 years	27	1·12	0·28	0·045	0·27	0·20	0·075	0·020
	15	2·14	0·20	0·020	0·14	0·10	0·040	0·020
	0	5·87	0·17	0·015	0·04	0·05	0·015	0·020
Scots pine	44	0·63	0·52	0·070	0·30	0·95	0·130	0·025
64 years	30	0·56	0·53	0·085	0·36	1·45	0·130	0·040
	15	0·55	0·52	0·075	0·30	1·45	0·095	0·035
	0	3·26	0·25	0·025	0·07	0·45	0·020	0·035

tree and to the bark of Corsican pine confirms work on this species by Ramann (1881) and Will (1882).

Wood. Variations in the nutrient content of wood in the main stem are shown diagrammatically in Fig. 1 (*a*) and (*b*).

Apart from the higher Mg and Na levels and larger heartwood percentage in Scots pine, variations in the wood of both species are similar.

Considering vertical distribution of nutrients, N, P, and K values are slightly higher in both species at the top of the tree, but there is little difference between lower samples. There are, however, considerable variations in horizontal distribution. From the outside of a disk to the centre (i.e. as the wood gets older) the Ca content rises steadily. On the other hand highest N, P, and K levels are found in the outer rings, and heartwood, when present, has very low P and K contents. But in the rings immediately surrounding heartwood consistently higher levels of all nutrients except Ca are found, Mg and Na in particular show markedly higher values in these rings, but apart from this their distribution is similar to that of Ca.

2. *Variations between trees*

Table V shows differences in the nutrient content of the various organs of the two Corsican pines felled in plot C on the same day (i.e. illustrates differences between trees of the same age). The larger tree was a dominant with a height of 48 feet and a quarter girth of 7¼ inches. The smaller tree, 34 feet in height, q.g. 4¼ inches, was definitely suppressed.

The higher contents of P, K, and Mg in the needles, branches, and bark of the suppressed tree are probably an indication of the lower dry matter and total N contents rather than of a greater supply of P, K, and Mg. As might be expected,

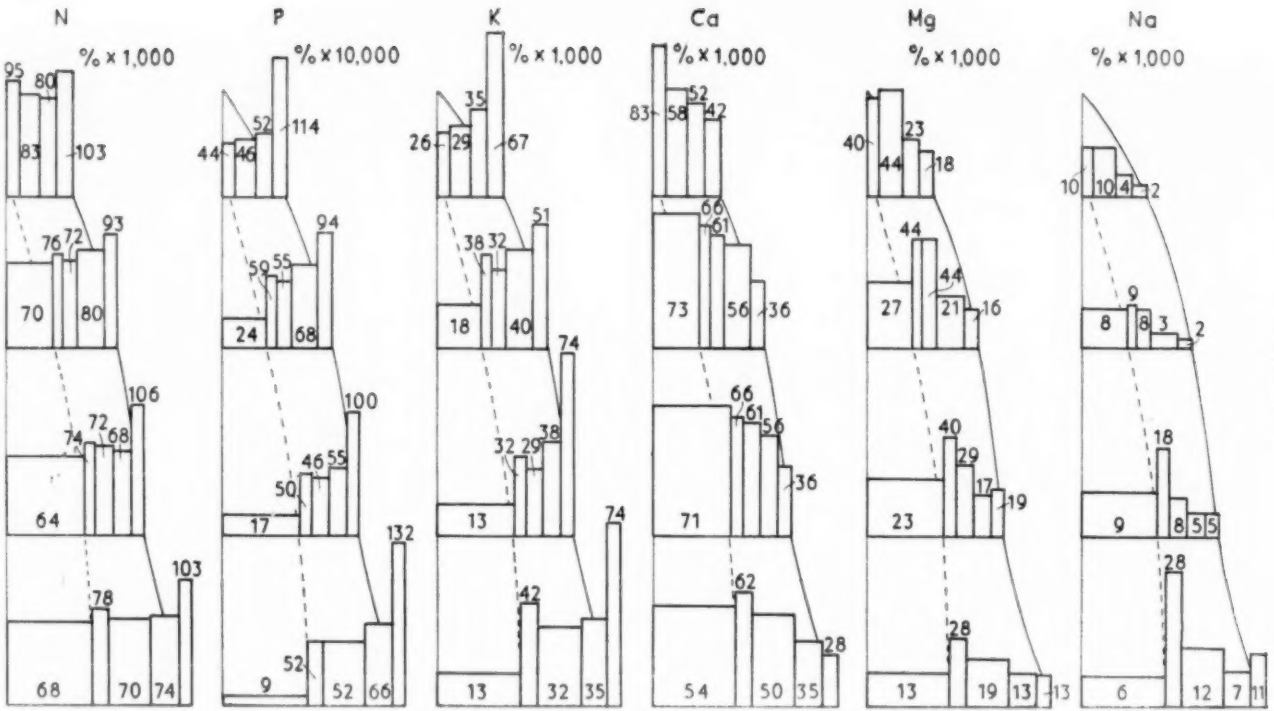

FIG. 1 (*a*). Nutrient contents in the wood of a 64-year-old Scots pine (height 53 feet; q.g.b.h. 7½ inches). Interrupted line shows limit of heartwood.

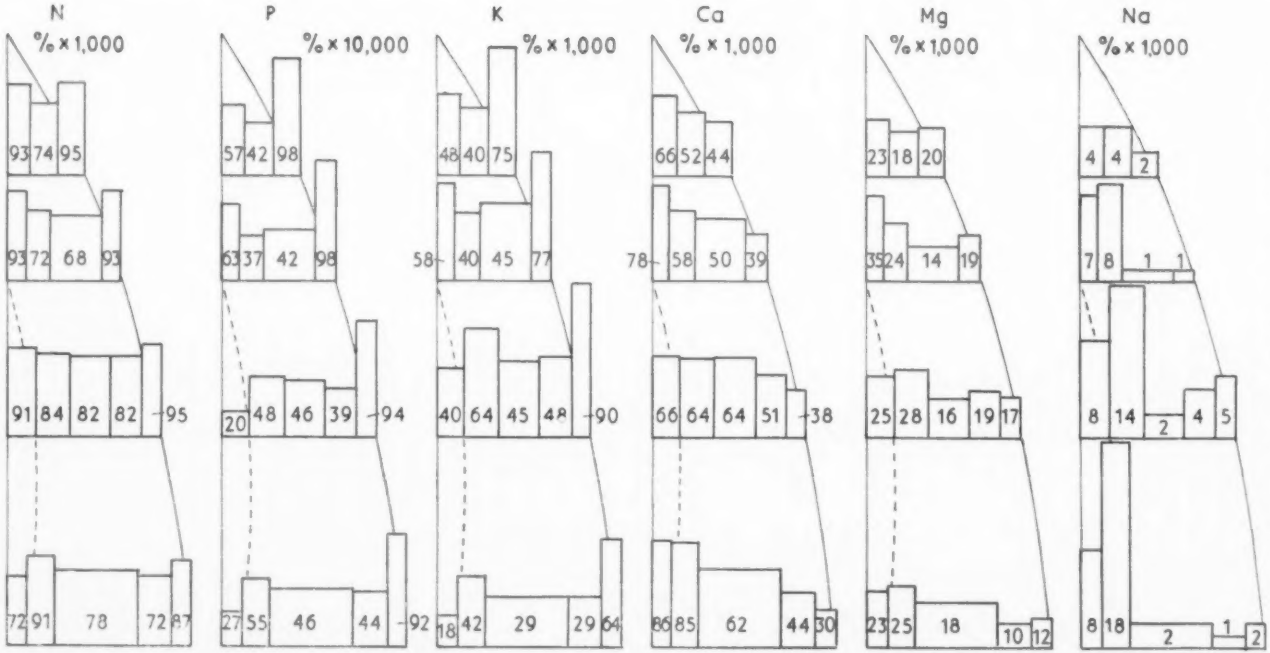

FIG. 1 (*b*). Nutrient contents in the wood of a 48-year-old Corsican pine (height 44½ feet; q.g.b.h. 6½ inches) .Interrupted line shows limit of heartwood.

there are no differences between the nutrient contents of the wood of the two trees except in the case of P: the suppressed tree had a greater percentage of heartwood, and since P is most affected by heartwood formation, this accounts for the lower average P content of the wood in this tree.

TABLE V. *Comparison of nutrient contents in dominant and suppressed Corsican pine*

		Total weight (*g.*)	*Percent. oven-dry material*					
			N	P	K	Ca	Mg	Na
Needles:	Dominant	7,400	0·90	0·115	0·66	0·42	0·075	0·035
	Suppressed	1,200	0·90	0·145	0·73	0·38	0·185	0·020
Branches:	Dominant	13,000	0·26	0·025	0·16	0·42	0·075	0·020
	Suppressed	3,300	0·27	0·035	0·25	0·30	0·100	0·025
Bark:	Dominant	26,600	0·21	0·025	0·11	0·12	0·045	0·020
	Suppressed	8,200	0·19	0·030	0·17	0·08	0·050	0·020
Wood:	Dominant	97,500	0·065	0·0060	0·05	0·045	0·015	0·015
	Suppressed	22,000	0·061	0·0045	0·05	0·050	0·015	0·015

3. *Seasonal variations*

To illustrate seasonal changes in the nutrient content of various organs, only the results from the two mean trees felled in June and December have been used, the values obtained from the two random trees felled in September being subject to the variations discussed above.

In the case of needles, the 1955 needles on the trees felled in June were compared with the 1955 needles on those felled in December. In the case of bark and wood, the values for the bark from the upper stem and the wood from the outer five rings only have been used, since it has already been shown that the nutrient content of older bark and wood tends to remain constant and would mask seasonal variations in the younger parts.

Very little seasonal variation was found in Ca, Mg, and Na in any part of the tree, but the figures for N, P, and K are shown in Table VI.

P and K levels rise in the needles from June to December but tend to fall in all other parts of the tree; particularly is this so in the youngest trees. This rise in the content of the needles has been noted and discussed by Wright (1957). N levels show some variations but no definite trends occur other than in the bark where contents rise; here again the difference is most noticeable in the youngest trees, where the N content of the bark in both species in December is twice that in June. These changes are further evidence of the seasonal movement and storage of nutrients in different parts of the tree suggested by Tamm (1955).

4. *Total nutrients per tree and per acre*

From the weights and percentage nutrient contents of the various needle, branch, bark, and wood samples, the mean total nutrient content of the three age classes and two species was obtained. In the case of the wood, the weights per

tree were calculated from the measured volumes and the density determinations made on each disk. The density of the disks from a single tree increased slightly towards the base of the stem but always fell within the limits of 0·39–0·48 g. per c.c. found in other Scottish samples (Forest Products Research Laboratory, 1957).

TABLE VI. *Seasonal variations in the* N, P, *and* K *contents of the different organs*

	Age (years)	*Sampling date*	*Corsican pine percent. dry weight*			*Scots pine percent. dry weight*		
			N	P	K	N	P	K
Needles	18	June	0·95	0·105	0·47	0·91	0·100	0·45
		Dec.	0·86	0·130	0·63	1·06	0·120	0·61
	28	June	0·67	0·080	0·45	1·40	0·135	0·51
		Dec.	0·86	0·160	0·69	1·46	0·185	0·59
	48, 64*	June	0·95	0·105	0·45	1·20	0·125	0·38
		Dec.	0·89	0·120	0·81	1·42	0·150	0·61
Branches	18	June	0·34	0·055	0·32	0·32	0·045	0·33
		Dec.	0·38	0·035	0·19	0·21	0·025	0·16
	28	June	0·20	0·035	0·22	0·49	0·075	0·40
		Dec.	0·24	0·030	0·20	0·40	0·040	0·20
	48, 64*	June	0·28	0·050	0·29	0·30	0·040	0·20
		Dec.	0·30	0·040	0·26	0·26	0·030	0·18
Bark	18	June	0·32	0·065	0·25	0·37	0·060	0·38
		Dec.	0·61	0·035	0·20	0·77	0·050	0·26
	28	June	0·24	0·040	0·18	0·48	0·075	0·43
		Dec.	0·27	0·035	0·24	0·60	0·085	0·47
	48, 64*	June	0·26	0·045	0·25	0·38	0·070	0·27
		Dec.	0·28	0·040	0·23	0·52	0·075	0·32
Wood	18	June	0·102	0·0165	0·106	0·083	0·0110	0·084
		Dec.	0·076	0·0050	0·037	0·085	0·0065	0·083
	28	June	0·060	0·0055	0·048	0·090	0·0115	0·065
		Dec.	0·065	0·0055	0·043	0·096	0·0080	0·064
	48, 64*	June	0·071	0·0080	0·092	0·081	0·0085	0·070
		Dec.	0·092	0·0095	0·076	0·101	0·0110	0·066

* Corsican pine 48 years, Scots pine 64 years. In the younger plots both species were the same age.

Little variation occurred in average density between trees or species, so a figure of 0·43 (26·8 lb. per cu. ft.) has been assumed for all trees.

Fig. 2 shows the increase in the total amounts of nutrients in a tree with age, and the distribution of each nutrient between the parts of a tree. Na results have been omitted because of inaccuracies introduced by the very low Na contents in wood; in any case this element is not of major importance in tree nutrition. The

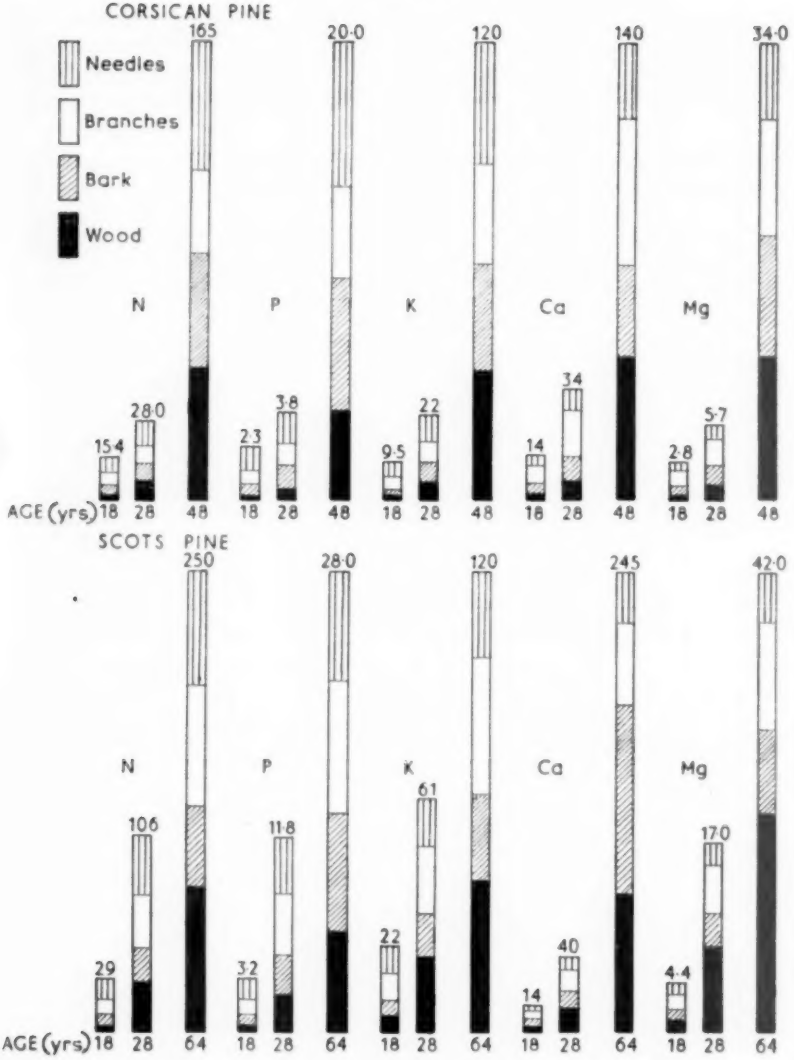

FIG. 2. Distribution of nutrients within the trees at three ages. Numerical values are total weights (g.) per tree.

figure shows in particular the abrupt increase in the Ca content of older Scots pine, resulting from the accumulation of dead bark and heartwood formation. In Corsican pine, where bark is laid down more uniformly and heartwood formation is not so great, this effect does not occur.

Table VII shows the percentage distribution in the various organs of the two species and its variation with age.

In both species the proportion of nutrients in the needles falls with increasing age, while the proportion in the wood increases. The increase in the percentage of Mg in the wood of older Scots pine is particularly noticeable and confirms the

TABLE VII. *Percentage distribution of nutrients in the different parts of the crop*

		Percentage of total				
		N	P	K	Ca	Mg
Plot A	Needles	39	43	39	26	22
C.P. 18 years.	Branches	27	27	31	39	36
	Bark	22	22	17	22	27
	Wood	12	8	13	13	15
Plot B	Needles	32	38	32	19	19
C.P. 28 years.	Branches	23	23	25	41	35
	Bark	23	27	23	22	26
	Wood	22	12	20	18	20
Plot C	Needles	28	32	27	17	18
C.P. 48 years.	Branches	19	20	22	32	25
	Bark	25	29	23	20	26
	Wood	28	19	28	31	31
Plot D	Needles	39	38	32	22	25
S.P. 18 years.	Branches	26	30	31	34	30
	Bark	20	20	18	24	19
	Wood	15	12	19	20	26
Plot E	Needles	30	29	20	17	12
S.P. 28 years.	Branches	27	31	29	29	25
	Bark	17	20	18	23	18
	Wood	26	20	33	31	45
Plot F	Needles	25	24	19	11	11
S.P. 64 years.	Branches	26	29	29	18	23
	Bark	18	25	19	41	18
	Wood	31	22	33	30	48

observations of Ramann (1881) and Will (1882). The proportion in the branches and bark remains fairly constant.

A combination of Table I and Fig. 2 gives total amounts of nutrients per acre in each species and age class. These values appear in Table VIII.

In the oldest age classes of both species, approximately half of the total content of all nutrients considered lies in the bark and wood of the stem, while in the younger trees the proportion is about one-third. Removal of the whole stem with bark in utilization will therefore result in the loss from the site of this proportion of the nutrients in the crop, even though the needles and branch wood are left in the forest. In the youngest stands, especially, barking of the stems before

removal will considerably reduce the loss, but the amount of nutrients removed in the wood alone is still appreciable.

Remezov (1956) has drawn attention to the fact that maximum immobilization

TABLE VIII. *Total dry weight and nutrient content of the crop*

		lb. per acre					
		Dry matter	N	P	K	Ca	Mg
Plot A	Needles	2,800	28·0	4·6	17·0	17·0	2·9
C.P. 18 years.	Branches	5,700	19·5	2·9	14·0	25·0	4·7
	Bark	4,400	16·0	2·3	7·5	14·0	3·5
	Wood	10,100	8·5	0·9	5·5	9·0	1·9
		23,000	72·0	10·7	44·0	65·0	13·0
Plot B	Needles	4,300	29·0	4·6	23·0	21·0	3·5
C.P. 28 years.	Branches	9,700	21·0	2·8	17·5	45·0	6·4
	Bark	11,500	21·0	3·3	16·5	24·0	4·8
	Wood	35,500	20·0	1·5	14·0	20·0	3·7
		61,000	91·0	12·2	71·0	110·0	18·4
Plot C	Needles	5,000	46·0	6·3	32·0	24·0	6·1
C.P. 48 years.	Branches	10,000	31·5	4·0	26·0	45·0	8·5
	Bark	19,000	41·5	5·8	27·5	28·0	8·9
	Wood	66,000	46·0	3·8	33·5	43·0	10·5
		100,000	165·0	19·9	119·0	140·0	34·0
Plot D	Needles	5,500	53·0	5·6	33·0	14·0	5·1
S.P. 18 years.	Branches	11,700	35·0	4·4	32·0	21·0	6·1
	Bark	6,500	27·0	3·0	18·5	15·0	3·9
	Wood	25,300	20·0	1·8	19·5	12·0	5·3
		49,000	135·0	14·8	103·0	62·0	20·4
Plot E	Needles	4,200	60·0	6·4	23·0	13·0	3·8
S.P. 28 years.	Branches	12,500	54·0	6·9	33·5	22·0	8·0
	Bark	7,500	34·0	4·5	20·5	18·0	5·8
	Wood	59,800	52·0	4·5	38·0	24·0	14·4
		84,000	200·0	22·3	115·0	77·0	32·0
Plot F	Needles	4,200	45·5	4·9	17·0	20·0	3·4
S.P. 64 years.	Branches	14,900	47·5	5·9	26·0	32·0	7·1
	Bark	12,700	33·0	5·1	17·0	74·0	5·6
	Wood	74,200	57·0	4·4	29·0	54·0	14·9
		106,000	183·0	20·3	89·0	180·0	31·0

of nutrients in a forest stand occurs during middle age. The results in Table VIII show that the total nutrient content in Corsican pine is still rapidly increasing at 48 years, whereas in Scots pine at 64 years the peak has already been passed and the total N, P, and K content is beginning to decrease, due to lower contents of these nutrients in the needles and a greater proportion of wood in the tree. In the case of Ca, however, the amount immobilized in the crop is continuing to rise

due to the accumulation of Ca in older organs, particularly the heartwood. In considering the effect of age on the immobilization of nutrients by the tree crop it is important to make this distinction between N, P, and K on the one hand and Ca on the other.

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H. R. BLANFORD: AN APPRECIATION

By Sir ARTHUR GOSLING

HARRY RICHARD BLANFORD died at his home in Fleet, Hampshire, on the 19th of December 1957.

One of the last of the probationers for the Indian Forest Service to complete their training at Cooper's Hill, he went to Burma in 1905 and soon began to earn a reputation as a promising silviculturist. His work in the Katha and Tharrawaddy forest divisions was interrupted by the war, when he was on timber supply work; but it was no surprise that, when in 1920 the post of Silviculturist was created, he was selected to fill it.

In 1924 he became Conservator, Working Plans Circle, a post which he filled with outstanding ability. When he left it about ten years later the greater part of the vast forest estate had been brought under simple, effective plans of management and control. He became Chief Conservator in 1935, but barely 18 months later was compelled by ill health to leave the Tropics.

Fortunately that did not mean the end of Blanford's forestry activities. In 1938 he became Editor-Secretary of the Empire Forestry Association and for 14 years was the king pin of that organization. He piloted it through the difficult war years, and when peace came was ready and able greatly to expand its activities and influence. This he did with little reward other than the personal satisfaction of furthering the cause of forestry. He had a firm belief in the value of the Association, and no-one could have done more than he did to prosper its aims.

He served for many years on the Standing Committee of the British Empire Forestry Conferences, and was a member of the Colonial Advisory Committee on Forestry. His contributions were always clear, definite and constructive—a more helpful colleague one could not find. He was awarded the C.B.E. in 1951.

The high standard of the Empire Forestry Association's journal, the *Empire Forestry Review*, demonstrated his ability as editor. Mention must also be made of the publications prepared by the Association for the British Commonwealth Forestry Conferences. *The Forest, Forestry and Man* was presented to the 1947 conference, the *British Commonwealth Forestry Terminology, Part I* to the 1952 Conference, and *Part II* to the 1957 Conference.

Blanford was never one to seek the limelight. When, in Ottawa in 1952, the Chairman of the Conference amid applause paid a special tribute to him for the tremendous personal effort he had put into the publication of Part I of the Terminology, Blanford's reply was typical: 'Thank you, Mr. Chairman. May I say I have merely been the office boy for a number of experts who have been responsible for the actual work.'

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FIG. 1. The distribution of Forestry Comm

f Forestry Commission forests in south-west England.

THE FORESTS OF SOUTH-WEST ENGLAND

By G. D. ROUSE and H. L. EDLIN

(*Forestry Commission*)

SUMMARY

South-west England is put on the forester's map; and its forests are briefly described, with particular reference to those of the Forestry Commission. The main silvicultural problems are discussed and the methods adopted for tackling them both on experimental and more extensive field scales are stated. The distribution of conifer plantations by species, age class, and quality class is given in tabular form. The current and estimated future volumes of thinnings are stated, and an indication is given of some of the major management problems which will arise in the future. Brief descriptions are given of 28 individual forests.

GEOGRAPHICAL INTRODUCTION

THE south-western peninsula of England is here taken to comprise the three counties of Cornwall, Devon, and Somerset, which have a total land area of 3½ million acres. A glance at a map of Great Britain will show that they lie well to the west of the rest of England (though not of Wales or Scotland), and in general much farther south. The greater part of Devon and nearly all Cornwall have a more southerly latitude than the Sussex Coast. The extremes of latitude are 50° and 51° 30′ North, and those of longitude 2° 10′ and 5° 40′ West. Land's End in Cornwall is the westernmost point in England, and the Lizard nearby is the most southerly headland of the British mainland. The peninsula, as so defined, has a length along its south-westerly axis of 170 miles; it tapers irregularly from its general width of 50 miles in the north-east to the narrow Land's End promontory, and hence no part of it is over 25 miles from the sea. This exposed situation between the Bristol Channel and the English Channel—reaching in effect far out into the Atlantic remote from other land masses—gives the peninsula a markedly maritime climate. Characteristics of this are mild winters, warm summers, a long growing season and relative freedom from frost, but a high degree of exposure to wind. In many districts the majority of winds can be described as sea breezes or gales; they are often salt-laden and have a severe moulding effect on tree form in exposed situations. The map (Fig. 1) shows the situation of the 28 Forestry Commission forests in relation to the seaboard.

The influence of exposure is increased by the general topography, for most of the south-west consists of high tablelands that fall steeply to the sea, often in sheer cliffs. The general elevation lies around 600 feet above sea-level, but the plateaux are deeply cut by countless winding streams and their associated valleys. Dartmoor, Exmoor, and Bodmin Moor have much ground over 1,500 feet elevation, and the highest point in the peninsula, High Willhays on Dartmoor, reaches 2,039 feet. The Quantock Hills, the Blackdown Hills, and the Mendips all touch 1,000 feet. There is only one extensive lowland in the region, namely Sedgemoor in Somerset, which lies virtually at sea-level.

The generally mild climate with long spells of warm sunshine in the summer and an adequate or plenteous rainfall is conducive to rapid tree growth where other factors are also favourable; but the mildness and shortness of the winter is not an unmitigated blessing, for a sudden sharp frost as late as November or as early as April, though uncommon, can have devastating effects.

Weeds luxuriate in the nurseries and there is no month in the year when such troublesome ones as the grass *Poa annua* and the chickweed *Stellaria intermedia* will not produce ripe seed.

Insect pests, too, may on occasion produce one more generation each season than occurs farther north. Scots pine poles, felled at Halwill as late as early October 1955, were infested with the pine beetle, *Myelophilus piniperda*, which matured before the winter; and it is not exceptional for breeding activity to start again by the last week in February.

The geological structure of the peninsula is too complex for discussion here, but in brief terms it includes various formations from the Devonian to the Tertiary Ages. The older and harder rocks lie to the west, the younger ones to the east, but there is no simple or orderly succession. Igneous rocks are frequent in the west and include the granites of Land's End, Bodmin Moor, and Dartmoor, and the serpentine of the Lizard. Due to its southerly situation, the peninsula escaped the severe glaciation that affected most of Britain, and surface deposits are rarely substantial.

HISTORICAL

In the south-west, woodlands occupy rather less than the average proportion of the land surface; the percentages are 4·0 for Cornwall, 6·1 for Devon, and 4·7 for Somerset, or 5·2 per cent. overall; as compared with 5·8 for England as a whole. Several factors appear to have favoured the widespread clearance of the peninsula's original woodland cover. First, the favourable maritime climate makes farming, and particularly dairy farming, practicable and profitable on steep slopes that elsewhere would be left under trees. Second, the moorlands, such as Exmoor, Dartmoor, and Bodmin Moor are, or have formerly been, subject to common grazing rights; whatever tree cover they once possessed has therefore vanished, and they are now used for raising cattle and ponies, as recreational areas—often in the form of National Parks—or as military training grounds. Third, the peninsula as a whole is rich in minerals, and the cutting of mine props, firewood, and charcoal wood on a coppice system for smelting ores has, in many districts, outstripped regrowth. Associated with this coppice working was the harvesting of oak bark for local tanneries, a trade that still continues on a small scale. Finally, the whole region has a long history of human settlement, evidenced by frequent prehistoric remains and by the old Celtic culture of Cornwall.

Historically, and to some extent topographically, the south-western woodlands fall into three broad classes:

I. Remnants of natural woodland scattered along the steepest valley sides, often difficult of access and obviously unsuited even to the intensive farming that here prevails. Oak coppice or scrub predominates.

II. Woodlands established around country houses by landowners during the eighteenth and nineteenth centuries. These show the characteristic features of park and amenity planting, shelterbelts, and small formal plantations found elsewhere in Britain, and much the same assortment of species, both broadleaved and coniferous.

III. Plantations established on moorlands, mostly during the twentieth century by the Duchy of Cornwall, water-supply authorities, certain private landowners, and the Forestry Commission. These are largely of conifers, with the spruces predominating.

In general, the private estate woodlands mentioned under II and III above have been well maintained by their owners. Some have been offered to the Forestry Commission for replanting, but many owners prefer to operate their woods themselves, and to participate in the Dedication and Approved Woodlands schemes. In particular, the estates of the Duke of Bedford, Lord Clinton, the Acland and Luttrell families, and the Dartington Hall Trustees have been noteworthy for their share in the development of private forestry. Sir Francis Acland, Bt., M.P., was Chairman of the Committee which produced the well-known report which led, in 1919, to the establishment of the Forestry Commission on which he served until his death in 1939. Lord Clinton, who died as recently as 1957, was also an original member of the Forestry Commission, and its Chairman from 1927 to 1930.

The need for vigorous action to restore the woodlands of the south-west is shown by the following figures taken directly from the 1947 Census returns of the Forestry Commission (Census Report No. 5. H.M.S.O., published 1953), which admittedly reflect the considerable fellings of the 1939–45 war, and take no account of subsequent progress.

	Cornwall	Devon	Somerset
(*a*) County			
(*b*) Total woodland area, acres	34,528	101,574	48,574
(*c*) Woodland classed as coppice, scrub, devastated, or felled (acres)	14,891	31,495	21,444
(*d*) (*c*) as proportion of (*b*)	43%	30%	44%

EXTENT AND CLASSIFICATION OF THE FORESTRY COMMISSION'S FORESTS

The Forestry Commission's forests in the counties of Cornwall, Devon, and Somerset are growing under such widely different conditions of climate and soil that it is not possible to treat them together for descriptive purposes. The following broad types are distinguished partly on a basis of previous land use, and partly by geological features.

I. *Former woodland*

A. Hill and valley sides, too steep for agriculture, mainly old devastated or felled woodland, or oak coppice; often with downwash soils.

II. *New afforestation areas*

B. Exposed moorlands, often having pan or compacted layers in the soil.

C. Culm clays.
D. Hard gravel hill tops of south-east Devon, usually associated with more fertile lower slopes of Greensand and New Red Sandstone.
E. Lower-lying, more sheltered areas, on soils derived from Triassic and Jurassic.

The forests as a whole, their extent and the type or types to which they may mainly be allotted, are set out in Table I by counties, all areas being in acres. This shows the position at the close of Forest Year 1957.

TABLE I. *Areas (acres) and types of forests in Cornwall, Devon, and Somerset*

County	*Forest*	*Area under plantations*	*Awaiting planting*	*Other land*	*Total land*	*Forest types*
Cornwall	Bodmin	1,240	84	167	1,491	A (B)
	Croft Pascoe	15	97	..	112	B
	Glynn	1,969	417	132	2,518	A (B)
	Herodsfoot	655	136	26	817	A
	St. Clement	256	21	5	282	A
	Wilsey Down	1,138	144	64	1,346	B (A)
	Total	5,273	899	394	6,566	
Devon	Bampton	96	116	..	212	B (C)
	Dartmoor	1,689	..	598	2,287	B
	Eggesford	902	121	18	1,041	A (C)
	Erme	155	485	2	642	A
	Fernworthy	1,501	..	4	1,505	B
	Haldon	3,357	384	52	3,793	D (C)
	Halwill	3,779	63	748	4,590	C
	Hartland	1,688	260	180	2,128	C
	Honiton	352	694	29	1,075	D
	Lydford	546	9	42	597	A (C)
	Molton Woods	197	198	..	395	A
	Okehampton	476	4	39	519	C
	Plym	1,220	168	4	1,392	A
	Total	15,958	2,502	1,716	20,176	
Somerset	Brendon	2,215	221	299	2,735	A (B)
	Bruton	968	61	6	1,035	E
	Dunster	1,264	342	417	2,023	A (B)
	Mendip	942	197	84	1,223	B
	Neroche	851	1,330	54	2,235	E
	Quantock	2,206	205	355	2,766	A (B)
	Sedgemoor	280	151	..	431	E
	Shepton	155	3	2	160	B
	Stokeleigh	444	188	7	639	A (E)
	Total	9,325	2,698	1,224	13,247	
Grand total for three counties		30,556	6,099	3,334	39,989	

SILVICULTURAL PROBLEMS

Type A. Old woodland on hillsides

Only in the rarest of cases is oak coppice fit for conversion to high forest by the selection and retention of the best stems, being generally too small, twisted, and slow growing.

Three methods of treatment have been adopted.

1. *Clear felling and replanting.* It was usual in the past to clear fell coppice, and plant a quick growing crop to smother coppice regrowth. Japanese larch (*Larix leptolepis*) was frequently used and some success has been achieved with this, but certain problems loom ahead. After the third or fourth thinnings the canopy becomes so light that dense ground vegetation comes in, usually with thick brambles and vegetational indications of soil deterioration. One proposal is to treat the Japanese larch as a catch crop, felling it in belts or groups whilst the ground is still clean, and replanting; the soils on the lower slopes are occasionally good enough for beech (*Fagus sylvatica*) with a conifer nurse. Another is to thin it out heavily at a relatively early age and to underplant.

Other species have also been used in the 'clear-felling and replanting' method of coppice conversion, and two are worthy of mention.

(i) Douglas fir (*Pseudotsuga taxifolia*) was used in some of the earliest Commission planting, and there are now stands carrying big volumes, particularly at Eggesford; but as one progresses westward this species looks increasingly unsuited to the site, the main feature being the lack of density in the crown. Where some of the Douglas fir failed on the lower slopes of the Quantock Hills and were beaten up with Sitka spruce (*Picea sitchensis*) trees of this latter species are now 20 per cent. greater, both in height and volume.

(ii) Western hemlock (*Tsuga heterophylla*) has been used more recently and to a lesser extent. For the first few years it puts up a very slender leader and exerts no repressive effect upon the coppice and weed growth; but it can hold its own with relatively little weeding and cleaning, and once it reaches the thicket stage it rapidly produces a dense shade which totally suppresses all other vegetation.

2. *Planting under the coppice.* After a minimum of preparation of ground in the way of clearing the shrub layer, and thinning out a little of the densest groups of stool shoots it is practicable to plant a future main crop under the cover of the standing coppice.

Norway spruce (*Picea abies*) was the tree most frequently used for this purpose in the past, but hemlock is now found to be the most suitable, though the following species are being tried on a more limited scale and are showing good promise; Douglas fir, *Thuja plicata*, *Abies grandis*, Lawson cypress (*Chamaecyparis lawsoniana*), and beech.

Within a year or two of planting more light is required, and this is obtained by girdling a proportion, usually between one-third and one-half, of the overcrop. With oak this operation can, for a period of about a month in the late spring or early summer, be combined with stripping the bark from the bottom 6 feet of the standing poles, since local tanneries still purchase oak bark. Such work is

doubtfully economic in itself, but it may occasionally help to employ a gang of men over a difficult period before the necessity for weeding of young plantation arises.

The remaining oak poles are similarly treated in one or two stages as the young crop develops. In certain cases, where extraction is not too difficult, it has been possible to sell the dead oak poles, standing, for firewood.

This method has the great advantage that it preserves the forest soil, but it may disturb those who are used to practising their silviculture in more northern climes to see the density of canopy which is left over the young crop. It would seem, however, that the greater intensity of sunlight in this southern extremity, together with the high proportion of hours of bright sunshine, justify this treatment.

3. *Clearance by dozer raking, followed by replanting.* The powerful modern dozer rake, mounted on a crawler tractor, has been used on a small scale mainly where the woodland is young birch (*Betula* spp.), sallow (*Salix* spp.), laurel (*Prunus laurocerasus*), or rhododendron (*Rhododendron ponticum*). The vegetation can be readily swept into racks, and the cleared ground can then be planted, with or without ploughing. But it is not usually possible to burn the racks because of soil piled among the roots and other debris; hence the racks themselves become a potential harbour for vermin. This treatment also strips off much of the topsoil, and the reduction in fertility of the site is indicated by the growth of such weed species as dwarf gorse and gorse (*Ulex* spp.), heather (*Calluna vulgaris*), and the grass *Agrostis setacea*. Reduced growth of the planted crop results, and the method appears applicable only to limited and exceptional areas.

Type B. Exposed moorlands

In the long narrow peninsula of Cornwall there is no land really far from the sea, and exposure to the winds coming straight off the sea appears to have a more discouraging effect on growth than does general high altitude exposure. Thus at an altitude of only 300 feet at Croft Pascoe on the Lizard Peninsula, the constant south-west sea wind is probably the limiting factor to tree growth, whereas at elevations of over 1,500 feet at Fernworthy on the eastern side of Dartmoor, trees of 70 feet in height are still growing vigorously.

At Wilsey Down in Cornwall, at an elevation of 1,000 feet, Sitka spruce planted in the early 1930's has remained obdurately in check and even now, over an area of more than 100 acres, the average height does not exceed 4 feet. Recent research indicates that the problem may be largely nutritional and experiments now in progress show a quite phenomenal response to the application of phosphates. On this difficult site lodgepole pine (*Pinus contorta*) has been used with some success, but the wide variations in results show the necessity for closer attention to be paid to strains and seed origins. Most striking is the comparative success of Lawson cypress, which is the only species to have completely suppressed the dominantly *Calluna* vegetation. It is perhaps significant that this species is the one to show the least response to the application of phosphates, and it might merit more extensive planting on difficult exposed sites if a strain could be found free from fluting and the tendency to frequent forking.

Pinus contorta produces other problems; it has been used as a nurse in very

FIG. 2. St. Aubyn Estate, Marazion, Cornwall *Eucalyptus gigantea*, planted in 1951; now 7 years old. Trenewjack Plantation

PLATE III

FIG. 3. Croft Pascoe, South Cornwall. *Pinus radiata* and *P. pinaster*, planted in 1954; now 4 years old. Broom in background

FIG. 4. St. Clement, Cornwall. Douglas fir, *Pseudotsuga taxifolia*, and *Tsuga heterophylla*, planted in 1954 in stripped oak coppice; now 4 years old

PLATE IV

FIG. 5. Bodmin, Cornwall. Douglas fir, *Pseudotsuga taxifolia*, established under stripped oak coppice. A later stage than shown in Fig. 4

PLATE V

FIG. 6. St. Aubyn Estate, Marazion, Cornwall. *Pinus radiata*, planted 1930, photographed 1957. Height 65 feet, quarter girth at breast height: 15 inches

PLATE VI

Fig. 7. Maritime pine, *Pinus pinaster*, at Glynn Forest, Cornwall

Fig. 8. Hauling thinnings from Douglas fir plantations, Eggesford Forest, Devon

PLATE VII

FIG. 9. Japanese larch, *Larix leptolepis*, with dense undergrowth of *Rubus* sp. Planted 1932, photographed 1957. Bodmin Forest, Cornwall

FIG. 12. Plantations in the Luxborough Valley, Dunster Forest, Somerset.
Photograph by permission J. D. U. Ward

PLATE VIII

intimate mixtures with Sitka spruce which in almost all instances it has rapidly outgrown. It would in the worst cases have been possible to convert the mixtures to pure stands of pine if it had not been for the extremely poor form of the strains of lodgepole pine used. Where the Sitka spruce had already started to make growth, as at Dartmoor, the pine side branches were cut back to give the spruce more light, but elsewhere, as at Kennisham Hill at Brendon, the pine early established complete supremacy and, owing to the wide spacing, the large knots and swollen nodes render the timber valueless. The most promising treatment being tried in such cases is the poisoning of the pine as it stands. Considerable areas of this same mixture at Hartland will need attention within the next few years, but in this case, fortunately, the form of the pine is more acceptable.

In the 1920's, the planting of exposed moorland sites at elevations of over 1,000 feet was done, in places, with Corsican pine (*Pinus nigra* var. *calabrica*). This cannot be described as a complete failure, since for 20 to 25 years they grew normally and produced crops carrying over 2,000 hoppus feet per acre. It seems probable, however, that the site was at the extreme limit of their range; and a protracted spell of adverse climatic factors, culminating in the severe winter of January–March 1956, followed by a long spring drought, caused die-back and death over large areas at Brendon and Quantock Forests. The worst affected areas were felled, but those areas in which a fair proportion of the dominants remained alive were retained. It cannot be said that the plantations have recovered during the past more clement (1957) season, but at least the rate of dying-off has been checked.

On other elevated exposed sites, chiefly at Bodmin, Glynn, and Lydford Forests, the Corsican pine never did get away so well, and the superiority of Sitka spruce and lodgepole pine in such places is shown by the growth of beat-up plants of these species. It seems probable that in future greater reliance will have to be placed on Sitka spruce, lodgepole pine, and perhaps Lawson cypress in planting such sites.

Mention must be made here of the surprisingly vigorous growth of beech, which is frequently to be seen forming effective hedgerows even on the exposed heights of Exmoor. It is a feature of these hedges that however roughly they are treated, and at whatever season they are cut, they coppice profusely. They are, however, a little misleading in that they are planted on banks, and their roots are in a much better-drained soil than would be the case if trees were to be planted on the adjacent moorland. Also, these banks provide much needed shelter for cattle and ponies, and the ground in their immediate vicinity is frequently better manured than the open moorland.

Type C. The Culm Clays

The Culm Clays, derived mainly from the shales of a Carboniferous formation, occupy a large area of west and central Devon and north Cornwall, bounded on the west by the sea, on the north by a line from Barnstaple to Bampton, on the east by the valley of the Exe from Bampton to Exeter, and on the south by the granite masses of Bodmin Moor and Dartmoor. Their chief feature is a heavy

impermeable yellow clay, covered by a thin layer of brown clay loam frequently no more than 6 inches deep. This gives rise to two closely associated problems, drainage and depth of rooting medium. Much of the forest land lies on a gently undulating plateau between 500 and 600 feet above sea-level, and the natural species to plant are the spruces, with some Douglas fir on the better-drained slopes. After a usually slow start growth has in many places been good, but the roots of spruce and Douglas fir have nowhere penetrated the clay, and sporadic windblows have occurred during gales. Once such a gap has been opened up in a crop 40 feet high, it does not need further exceptional gales to extend it; every time high winds are associated with wet ground conditions more casualties occur.

It is noticeable that broadleaved species, particularly oak and to a lesser extent beech, are more windfirm, but unfortunately the site factors are such that plantations of these species would be quite uneconomic. On the bare clay, exposed when trees have been uprooted, goat willow (*Salix capraea*) has occasionally become established, the roots of one-year-old seedlings penetrating as far as a foot into the pure clay.

The establishment of a broadleaved fringe to plantations would not prove to be the easy solution to this problem in the future, since the windblows more frequently start in pockets well within the plantations; it seems that some more intimate mixture of relatively windfirm broadleaved trees and revenue-producing conifers is required.

It is important to get the gaps filled up as soon as possible to protect the exposed edges of the established crop, and the current practice is, firstly, to ensure adequate drainage and then to plant fast-growing conifers in mixture with beech. Beech is being used in preference to the firmer-rooting oak because it is more able to keep pace with the conifers.

Shallow and deep ploughing before planting have been practised in the past, but both these methods have resulted in confining the tree roots to the narrow strip of top soil between two adjacent furrows. In order to induce deeper rooting, it seems necessary either to improve drainage by subsoiling or to increase the depth of good tilth by some such method as gyrotilling.

Type D. The hard gravel hilltops of south-east Devon

These gravels differ from those in the Hampshire basin so successfully afforested in the New Forest, in their being cemented together in a matrix of white china clay which impedes drainage. Conditions are worst on the flat top of Haldon Hill, about 10 miles south of Exeter, and the proportion of clay decreases from the ridge above Ottery St. Mary eastward to the Devon–Dorset border. The Haldon gravels are of Tertiary (Eocene) age, but those farther east, though shown on the older geological maps as 'Greensand', are now considered to originate from some later Cretaceous formation; they are known as 'chert-beds'.

At Haldon Forest, on the land surrounding the race-course, Scots pine (*Pinus sylvestris*) was planted during the 1920's, but much of this has remained in check. Considerable areas were taken in hand again in 1937, when the ploughing technique on difficult sites was being developed, and the original Scots pine was

frequently replaced with Corsican pine; but the shallow ploughing and change of species only resulted in getting the crop a little taller before it, too, went into check.

In wet periods the level surface of the ground has been waterlogged; this led from time to time to beating-up, on turves or on the flat, with Sitka spruce, but only occasional specimens can now be found, very few of them exceeding 3 feet in height.

Improved drainage, coupled with deeper rooting, might solve the difficulty, and experiments have been started on ploughing and deep subsoiling; but it is yet too early to predict their success. An interesting experiment on a very small scale has involved the use of explosives to shatter the subsoil and thus improve drainage. Recent work at Wilsey Down Forest in Cornwall has shown that lack of nutrients may be an important factor, and so the application of phosphates, with and without the removal of the existing *Calluna* vegetation by means of the 'Roadless Brushcutter' machine, is also being tried.

Type E. Lower-lying more sheltered areas on Triassic and Jurassic soils

The main examples of these are at Neroche and Bruton Forests, and there it has been assumed, perhaps occasionally a little too readily, that the heavy clays and clay-loams should carry oak. On the deep moist soils oak shows promise, but on the shallower and drier sites, particularly where associated with Jurassic limestones, growth continues to be poor. In existing checked crops steps are being taken to introduce Norway spruce or other conifers. In areas still to be planted the use of oak will be restricted to the best deep moist soils; some soil cover will be retained wherever possible, in an endeavour to prevent the clay cracking open in periods of drought, and at least 50 per cent. of conifers will be incorporated in the crop.

PRODUCTION AND OUTPUT OF TIMBER

With such a wide range of growing conditions it is to be expected that the crops will vary greatly in quality, and this fact is borne out by Table II. The quality classes have been determined in accordance with the *Revised Yield Tables for Conifers in Great Britain* (Forestry Commission: Forest Record No. 24, 1953).

When plantations are just emerging from check and are composed of trees of different ages due to the beating-up of failures the assessment of height and age may be quite misleading and a quality class has been attributed to stands under 10 years of age only in cases of exceptionally good growth; such stands are generally shown in the table as unclassified (U/C). There are also stands where the height for a given age falls below the lowest recorded quality class, and these are also recorded as unclassified.

Where a plantation has been beaten-up with one or more different species but the original species remains dominant no allowance has been made for the later-introduced species; but where the original species will clearly not form the majority of the final crop the stand has been recorded under the new dominant

TABLE II. *Classification of Forestry Commission conifer plantations in Cornwall, Devon, and Somerset*

Species	Quality class	Top height at age 50 (ft.)	Areas in acres; age classes by year of planting: Prior to 1920	1920–9	1930–9	1940–9	1950–6	Totals for: Quality class	Species
Scots pine	I	70	20	63	10	46		139	
	II	60	4	140	16	34		194	
	III	50	12	331	3	75		421	
	IV	40	14	815	31	42		902	
	Unclassified		..	19	80	272	446	817	
	Totals		50	1,368	140	469	446	..	2,473
Corsican pine (& other pines)	I	80	1	1	28	68		98	
	II	70	4	29	46	58		137	
	III	60	2	36	119	11		168	
	IV	50	12	277	198	219		706	
	U/C		..	179	291	261	633	1,364	
	Totals		19	522	682	617	633	..	2,473
European larch	I	80	23	22	19	12		76	
	II	70	17	33	32	17		99	
	III	60	9	177	16	1		203	
	IV	50	16	174	73	..		263	
	V	40	5	101	3	..		109	
	U/C		30	20	8	3	59	120	
	Totals		100	527	151	33	59	..	870
Japanese larch	I	90	..	13	83	142		238	
	II	80	..	62	187	175		424	
	III	70	..	161	155	266		582	
	IV	60	3	32	32	10		77	
	V	50	..	44	14	4		62	
	U/C		..	38	19	202	1,334	1,593	
	Totals		3	350	490	799	1,334	..	2,976
Douglas fir	I	110	6	12	23	1		42	
	II	100	4	91	92	10		197	
	III	90	20	392	218	63		695	
	IV	80	2	1,251	354	50		1,657	
	V	70	..	483	80	..		563	
	U/C		4	62	73	66	400	605	
	Totals		36	2,291	840	192	400	..	3,759
Norway spruce	I	80	..	15	23	23		61	
	II	70	2	93	96	141		332	
	III	60	4	127	238	270		639	
	IV	50	1	1,030	340	194		1,565	
	U/C		..	187	212	187	656	1,242	
	Totals		7	1,452	909	815	656	..	3,839
Sitka spruce	I	110	1	54	6	35		96	
	II	100	6	120	27	15		168	
	III	90	1	114	178	64		357	
	IV	80	..	238	491	341		1,070	
	V	70	..	790	649	441		1,880	
	U/C		..	217	854	1,083	1,164	3,318	
	Totals		8	1,533	2,205	1,979	1,164	..	6,889
Other conifers	I		..	1	1	14		16	
	II		3	15	9	10		37	
	III		..	..	9	8		17	
	IV		..	1	11	36		48	
	U/C		..	3	42	91	810	946	
	Totals		3	20	72	159	810	..	1,064
TOTALS			226	8,063	5,489	5,063	5,502	..	24,343

species and for the purpose of determining quality class an estimated age has been allocated.

Where two species have been mixed from the beginning the area has been apportioned to each in the proportions in which they were originally planted.

This also applies where conifers were planted in mixture with broadleaved species.

To give a balanced picture, Table III shows the areas of broadleaved plantations:

TABLE III. *Classification of Forestry Commission broadleaved plantations in Cornwall, Devon, and Somerset*

Species	*Area in acres; age classes by year of planting*					
	Prior to 1920	1920–9	1930–9	1940–9	1950–6	*Total by species*
Beech . .	48	12	21	160	1,291	1,532
Oak . . .	411	9	94	209	286	1,009
Others . .	139	144	46	6	216	551
Totals . .	598	165	161	375	1,793	3,092

The difference between the combined totals of Tables II and III and the area of plantations shown in Table I is attributable to rehabilitated mixed woodlands, stored coppice, and mixed stands containing many different species.

It will be noted that over 60 per cent. of the broadleaved area has been planted within the present decade.

The need for the future treatment of our existing woodlands is quickly revealed by a study of Table II. There is a relatively large area carrying a crop of or below the lowest quality class, and these stands may be divided into three main groups:

(i) Areas of exceptionally low soil fertility, or, as at Mendip, positively toxic properties.

(ii) Areas of considerable exposure, or where vegetational conditions at the time of planting were particularly difficult.

(iii) Areas where the species originally planted is not the one best suited to the site, but may have been planted for a special purpose which has already been achieved.

The extent of land comprised in group (i), with which may be associated problems of drainage, is now well known, and the Research Branch has already made some advance towards finding a suitable treatment for certain types; it would therefore be wise to defer large-scale action here until an effective and economic treatment can be confidently prescribed.

The crops in group (ii) must be regarded as pioneers, and it is to be expected that they will take time to become effective; once they have provided the necessary shelter or suppressed the original vegetation it will be time to consider the introduction of more valuable species, but even in such cases it may be advantageous to avoid too hasty action since trees which make slow, knotty growth whilst they are competing with the surrounding vegetation may themselves become of greatly improved form once they develop a complete canopy.

It is in areas covered by group (iii) where it is proposed to make an immediate

start. The larches never were planted on intrinsically poor sites; the same may be said of Corsican pine, and to a lesser extent, of Scots pine.

The *Revised Yield Tables* show that at 40 years of age quality class V Sitka spruce has a mean annual increment of 121 hoppus feet per acre whilst European larch quality classes III, IV, and V have increments of only 62, 41, and 24 respectively, and the same argument can be adduced against the retention of the lowest quality classes of the pines. It is probable that Sitka spruce will form the major component of crops replacing the pines and Norway spruce at higher elevations and in exposed places, but Douglas fir and such shade-tolerant species as *Tsuga*, *Thuja*, and Lawson cypress will be used wherever conditions permit, and a place may be found for *Pinus radiata* and *Cupressus macrocarpa* in maritime localities when suitable strains have been identified and nursery technique improved.

The oldest plantations of the Forestry Commission were relatively small and widely scattered; the south-west has a preponderantly rural population; the traditional field boundary is a stone and earth bank topped by a beech hedge which coppices vigorously when cut down, and yields all the fuel wood and poles which the farmer needs; most of the private estates and many of the farms have goyles or steep-sided valleys which yield oak coppice poles of fair size and quality from which rough constructional timber and gate posts can be cut; the traditional market of oak charcoal and tan-bark has been killed by the vastly increased labour costs and imports of tanning materials, and hence much of the woodland skill has died in the rural communities; there were no major industries relying primarily on a regular supply of home-grown timber; the coastal shipping trade, which might have given cheaper transport of woodland produce to South Wales and other potential markets in England, has dwindled to insignificant proportions. For these reasons the marketing of produce from the young plantations has never been easy, but by strict adherence to the customer's specifications, the training of unskilled workers in the use of tools, and, more recently, by making full use of all forms of mechanization, a steady market has been built up, and the volumes of thinnings have so greatly increased recently that it has been possible to attract merchants to go even as far west as Bodmin to purchase thinnings standing.

During 1956, 320,000 cubic feet of conifers were sold standing, and approximately 500,000 hoppus feet (over-bark measure) felled and converted by direct labour. This was disposed of in the following categories:

	Hoppus feet
Saw logs	57,000
Mining timber	306,000
Posts, stakes, and rustic poles	22,000
Peeled wood-wool timber	15,000
Telegraph and selected poles	4,000

Firewood, bark, and other conversion losses account for the balance.

During the war years in the early 1940's the planting programme dropped, but it subsequently increased steadily to over 1,000 acres of conifers each year. From the data in Table II and reference to the *Revised Yield Tables* an estimate can

be made of the volumes to be expected from thinnings in the future, and those for the years 1960 and 1980 are shown in cols. 2 and 3 of Table IV.

If, however, the relatively unproductive areas, referred to above, are taken in hand during the next 5 years, the new plantations will already be yielding first thinnings by 1980; an estimate for the yield in 1980 revised on this basis is given in col. 4 of Table IV.

TABLE IV. *Estimated volumes of conifer thinnings by species, from existing plantations*

(1) *Species*	*Volumes (hoppus feet) in year* (2) 1960	(3) 1980	(4) 1980: *revised*
Scots pine	61,000	124,000	77,000
Corsican pine	60,000	148,000	140,000
European larch	24,000	26,000	12,000
Japanese larch	100,000	208,000	195,000
Douglas fir	294,000	307,000	364,000
Norway spruce	75,000	211,000	204,000
Sitka spruce	287,000	503,000	643,000
Other conifers	4,000	46,000	62,000
Total	905,000	1,573,000	1,697,000

The percentage of logs which will cut a minimum length of 6 feet with a minimum top diameter of 6 inches, is at present 28; by 1980 the proportion of saw logs will have risen to 40 per cent.

From the existing area of 24,343 acres of conifer plantations, thinnings will amount to approximately 1,700,000 hoppus feet in 1980, but at that time the total current annual increment from the same area will be in the neighbourhood of 3,700,000 hoppus feet. It is not possible now to forecast how much of the current increment will be annually felled by 1980; but it is certain that even if the foresters of that period have solved the major silvicultural problems they will still have the interest of many management problems before them.

REVIEW OF INDIVIDUAL FORESTS

The twenty-eight separate forests of the south-west are described individually below. The arrangement starts from the south-west, working from Cornwall through Devon to the north-east of Somerset. Forests enjoying similar conditions are grouped together so far as the context allows.

South-west Cornwall

Croft Pascoe

Croft Pascoe is a small and largely experimental forest started in 1954 on the isolated and exposed Lizard Peninsula, 5 miles from the southern extremity of Britain. It extends to 112 acres, but only 12 acres have been developed so far. The object is to test the possibility of economic timber production on the exposed flat tableland of the Goonhilly Downs,

350 feet above sea-level. This area has a substratum of the unusual serpentine rock; it carries a vegetation of gorse, *Molinia*, *Calluna* and *Erica* species, including the rare Cornish Heath, *E. vagans*, and the bog-rush *Schoenus nigricans*. Much land is currently unutilized, and further pieces may become available for planting, if that is found worth while. In experimental work by the Research Branch, most of the ground has been ploughed; the soil shows marked phosphate deficiency, and growth is only promising where phosphatic manures are applied. The principal trees under test are: *Pinus contorta*, *P. radiata*, *P. pinaster; Picea sitchensis*, *Abies nobilis*, and some of the more hardy *Eucalyptus* species, including *E. gunnii* and *E. globulus*. Early growth is promising, the eucalyptus being particularly vigorous.

Experiments include cultivations, manuring, trials of species, nursing with broom (*Sarothamnus*), and ancillary work connected with direct sowing of pines. So far, *Pinus radiata* appears the best prospect. Responses to phosphate are very large indeed, as might be expected as this soil is extremely deficient in this nutrient. No abnormalities directly attributable to the serpentine as such (nickel toxicity, &c.) have as yet appeared.

The forest is managed from St. Clement, and there is no resident staff.

St. Clement

St. Clement Forest comprises a block of former oak coppice on hillsides within the valley of the River Allen, 2 miles north of Truro; it covers 281 acres, all on Devonian rocks. It was acquired in 1952, and replanting is nearing completion. At first the practice was to clear the coppice prior to planting, using a mechanical dozer rake where appropriate. Now it is found better to introduce shade-bearers below the coppice, which is then gradually thinned to let in more light. Since a local market exists for tanbark, it is found worth while to strip standing oak coppice stems, in order to kill them. The main trees planted are Japanese larch, Douglas fir, Norway spruce, western hemlock, and beech. Research work includes two trials of hardy *Eucalyptus* species (growing well so far), a Douglas fir provenance trial to test their response to the long Cornish growing season, and tests of *Nothofagus* species, hybrid balsam poplars, and *Metasequoia glyptostroboides*. Within the woods are a large Iron Age camp and a ruined gunpowder mill which once used local charcoal; the rare royal fern, *Osmunda regalis*, is found in boggy patches.

Six men are employed.

The Bodmin Group of Forests

The town of Bodmin in mid-Cornwall is the centre for three forests, namely Bodmin, Glynn, and Herodsfoot, which show contrasts of very good and remarkably poor growth occurring almost side by side. The surrounding country forms a plateau of Devonian rocks averaging 600 feet in elevation and fully exposed to strong winds from both the Atlantic and the English Channel, since the peninsula is here only 20 miles across. Ground available for afforestation on the hilltops, locally called 'downs', has a fair depth of soil, only moderately leached, over broken rock, and supports a dense growth of heather, heaths, dwarf gorse, and coarse grasses. These site factors have so far proved unfavourable to all species tried, even when the slopes are ploughed; growth, though steady, is disappointingly slow for so southerly a situation.

A contrast is provided by the numerous winding valleys cut deeply into the plateau by the rivers Fowey, Camel, Looe, and their numerous tributaries. Owing to their steepness, the valley sides have remained under woods of oak coppice, now universally neglected; although this is costly to clear it provides excellent sites. The combination of shelter and a deep 'downwash' soil, which has never been bared of tree cover, is probably responsible for

the rapid growth. Main species are: Japanese larch (692 acres), Douglas fir (647 acres), beech (507 acres), Norway spruce (415 acres), and Sitka spruce (312 acres).

Bodmin Forest

Bodmin Forest consists of four blocks in the vale of the River Camel, two being north of Bodmin town and two south of Wadebridge. Conversion of oak coppices at the Dunmere and Helligan blocks, north of Bodmin, began in 1950, and is still in progress. The trees planted include Scots, Corsican, and lodgepole pines, European and Japanese larches, Douglas fir, Norway and Sitka spruces, western hemlock, Lawson cypress, *Abies grandis*, and beech. Of the two blocks south of Wadebridge, Bishop's Wood shows good growth of Japanese larch, which scales 50 feet after 24 years; Douglas fir is also vigorous, but has suffered some windblow. Grogley Down, farther south, has good Japanese larch and Corsican pine on the lower slopes. Higher up, the mixed crop of Corsican pine and Sitka spruce is poorer, reflecting the sterility of the gritty soil and the exposure at 600-foot elevation, though it is markedly better on one former arable field. For the later plantings, open downland has been ploughed, and lodgepole pine, Monterey pine, and Lawson cypress have been tried. The total extent of Bodmin Forest is 1,491 acres, and about fourteen people are employed.

Glynn

Glynn, which comprises 2,518 acres, consists of the large Cardinham Block east of Bodmin; woods along the Fowey Valley, where the main road and railway to the west follow the River Fowey, and a few outliers. The Cardinham portion, in a deep glen, was formerly oak coppice, but between 1922 and 1940 this was cleared, and the land replanted with conifers. On alluvial soil in the valley bottom Sitka spruce has proved outstanding, showing some of the fastest growth recorded in Britain; the largest individual reached 105 feet in 30 years, with a breast-height girth of 7 feet. Plantation heights of 75 feet at 30 years are frequent on the lower valley slopes, with annual increments of 300 hoppus feet per acre. Douglas fir and Japanese larch also do well, but European larch has fared badly. Thinnings now run at 40,000 hoppus feet a year. There is an old 'clapper' bridge across the stream, and the ruins of the old Hurtstocks tin mine may still be seen. The Fowey Valley woods are younger, and in places the conversion of oak coppice and birch scrub is still going on, being done gradually for amenity reasons. Douglas fir, larch, western hemlock, lodgepole pine, and Norway spruce are the main trees planted. On the valley floor there are examples of afforestation of rough river gravels, which were 'stream-washed' for tin ore in days gone by.

The southern outliers of Glynn are newly acquired and recently planted. They include some sterile downland at heights around 600 feet, fully exposed to southerly sea-winds. In places this is being ploughed before planting. The number of people employed averages twenty-three. An experimental project at Glynn compares various methods of dealing with a dense jungle of cherry laurel (*Prunus laurocerasus*), degrees of clearance, and trials of species as 'suppressors' of the laurel regrowth.

Herodsfoot

Herodsfoot consists of two large blocks of former oak coppices and four small outliers in the deep valleys of the Looe and West Looe rivers. They are centred on the hamlet of Herodsfoot, once a centre for mining silver and lead; spoil heaps and other workings are still evident.

The conversion of oak coppice to high forest began in 1935, using Douglas fir, Norway and Sitka spruce, Japanese larch, western hemlock, and a little *Thuja plicata*, red oak, and

beech. Growth is everywhere promising and some of the older Douglas fir and Norway spruce have reached the thinning stage. The total area is 817 acres, and nine people are employed. Experiments with some of the principal arboricides have been carried out at Herodsfoot; the most promising material is probably 2, 4, 5 T, applied as a basal bark spray.

Particular care is taken over fire protection as there is a gunpowder factory in the middle of the largest block.

Bodmin Moor

Wilsey Down

Wilsey Down Forest lies on the high ground of Bodmin Moor, in four blocks, totalling 1,346 acres. The oldest of these, Wilsey Down itself, 405 acres in extent, adjoins the Launceston–Camelford road, at elevations of 700–900 feet; exposure from all directions is severe. The soil is an infertile grit, derived from Culm Measures. The stands of Sitka spruce, Japanese larch, and lodgepole pine show remarkably poor growth, associated with a characteristic down vegetation of dwarf gorse (*Ulex gallii*), bell heather, cross-leaved heath, blue moor grass, and the grass *Agrostis setacea*. Planting began in 1928, but not until 1955 were any portions tall enough to require thinning.

Research is in progress on the root causes of this very slow progress, and the following points have emerged so far.

Pinus contorta planted as a nurse to the spruce on this site was unfortunately mainly of an unsuitable 'interior' provenance, and quite failed to suppress the vegetation. Experiments carried out on recently ploughed ground have compared a range of species in a matrix of *P. contorta* of coastal origin. Manurial experiments here have shown large phosphate responses in new plantations, but more surprisingly, 20-year-old spruce less than 3 feet high, in an apparently moribund condition, has also responded quite dramatically to broadcast dressings of phosphate, and that without any further cultivation or other treatment to suppress the ground vegetation. 'Check' of spruce on this site (as perhaps on other western heaths containing *Ulex gallii*) appears to be more a question of phosphorus than of nitrogen deficiency, and in this is unlike the typical check of eastern *Calluna* heaths. The question may be asked whether *Ulex gallii*, although almost certainly an indicator of poor site conditions, does not redeem itself to some extent by supplying a little nitrogen.

Halvana, the second portion, lies south of the Bodmin–Launceston road near Altarnun and is a block of 495 acres, on sloping moorland at 800 to 1,000 feet. The deep gravel soil overlies a grey granite but is itself topped with peat. Here there was formerly a copper and tin mine, and the old shafts may still be seen. Sitka spruces have thriven well on the moist peaty soils since they were planted between 1930 and 1940, and thinnings began in 1955. A recent problem is the roosting during the winter months of vast flocks of starlings which have poisoned and killed about 40 acres of thicket-stage Sitka spruce.

Davidstow, the third portion, stands 4 miles east of Camelford. Covering 300 acres, it occupies the site of a war-time aerodrome, the runways being still in evidence. At 950 feet elevation it is exposed to the Atlantic, 6 miles distant, but soil conditions are good and the young trees are thriving. Planting was done between 1951 and 1953, with Sitka spruce, lodgepole pine, and Japanese larch. There is a nursery of 10 acres where surprisingly good results are obtained, though exposure restricts height-growth.

Bicton Wood, the fourth and most recently acquired portion, extends to 155 acres, on the west bank of the River Lynher some 2 miles west of Callington. It carries a crop of oak coppice and scrub with some better sycamore poles. Conversion of the scrub areas started in 1957; Scots pine, Japanese larch, Douglas fir, Norway spruce, western hemlock,

and beech are the chief species used. Here, again, in the river valley old lead mine workings are in evidence. North-east aspect, mainly well sheltered, elevation from 200 to 500 feet.

Sixteen people are employed on the whole forest.

North-west Devon

Hartland

The exposed north-western shoulder of Devon that ends in Hartland Point consists of a tableland 700 feet high which slopes gently eastwards towards the River Torridge and its tributaries. Much of the farm land at the higher levels is marginal in character, and portions too poor even for grazing have gradually been acquired for forestry. Since 1937, a total of 2,095 acres has been acquired in 17 separate acquisitions. This lies mostly in two blocks, one west and the other (Melbury) east of Woolfardisworthy (pronounced Woolsery) village. The geological formation is Culm clay, which supports a vegetation of blue moor grass, heather, and gorse. Exposure to salt-laden gales is severe, and there are many local frost hollows. Nevertheless Sitka spruce, the main species grown, has generally made a good start. Norway spruce is used on a lesser scale, and the Scots and lodgepole pines only as nurses.

Land of quite different character is found in combes running steeply down to the sea. There are two such near Buck's Cross, facing north towards Bideford Bay, and others running towards the open Atlantic west of Kilkhampton, Cornwall. Here old oak coppices are gradually being replaced by larch and beech, and amenity is a major consideration.

Rare hawks, such as Montagus' harrier and the peregrine falcon, frequent this region, and a notable botanical rarity is the tussock sedge (*Carex paniculata*).

The labour force numbers thirteen.

Halwill

Running south-east from Holsworthy towards Okehampton and Dartmoor lies a belt of land that parts the Torridge valley on the north from that of the Tamar and its tributaries towards the south-west. The general elevation of this exposed land, which is followed by road and railway, is from 600 to 900 feet. The soil is a heavy Culm Measure clay; agriculture is marginal, and much land has gone back to blue moor grass, heather, and gorse. Since 1920, a forest of 4,582 acres has been built up by no less than 43 acquisitions spread over 30 blocks; this figure includes 720 acres of farm land. Originally Norway spruce (now 1,450 acres) and Sitka spruce (now 1,300 acres) were the main species. On land that had only recently been abandoned by farmers, growth was satisfactory; on former woodland it was excellent; but on the poorer moors the spruces went into prolonged check, despite ploughing prior to planting, and such areas are still patchy and poor. Scots pine (290 acres) and Douglas fir (105 acres) were also used early on; recently there has been a trend towards Japanese larch (260 acres) and lodgepole pine (425 acres), the last named being particularly vigorous here. About 900 acres, largely of spruce, are now at the thinning stage; thirty people are employed; several houses, a fire tower, and a depot have been built.

Here also the mass roosting of starlings has caused havoc to plantations of Sitka spruce in the thicket stage.

Okehampton

Most of this forest lies in two blocks north of Okehampton town on the northern fringe of Dartmoor, and has a subsoil of Culm clays. One block, of 370 acres, was formerly oak woodland and coppice; it has been converted since 1928 to conifers, largely Douglas fir and Japanese larch; these have grown well and portions have reached the thinning stage. The

other block, of 137 acres, is moorland in character, and has been afforested, mainly with Japanese larch and Norway spruce, since 1952. The total area is 519 acres, and the general elevation 500 feet; five men are employed.

Lydford

West of Lydford, a village on the western fringe of Dartmoor, the River Lyd drops steeply down into a wooded valley, which is followed by the railway towards Launceston. In 1933 the Commission acquired 464 acres of oak woodland and coppice, largely oak, for replanting. At the same time, 134 acres of moorland, at Burley Down north-west of Lydford village, was acquired for afforestation. The main species used were Japanese larch (183 acres), Corsican pine (142 acres), Norway spruce (80 acres), and Douglas fir (57 acres). Growth has generally been good, and some 200 acres are at the thinning stage. But the Corsican pine is disappointing; possibly the general elevation of 700 feet is too great for it. In 1957, 42 acres of felled woodland at North Park were added, bringing the total area to 639 acres. All the land lies on the Culm Measures; six people are employed.

South-west Devon

Plym

Plym Forest has been created since 1948, by the acquisition of 1,686 acres of former woodland in the valleys of the Rivers Plym, Meavy, and Tavy, between Plymouth and Tavistock. The topography is a plateau around 400 feet elevation, broken by irregular valleys falling to sea-level. The rocks are Upper Devonian shales, which here yield rich loams of varying depth. The woods comprise one large block near Plym bridge and six smaller ones. Favourable soil and situation have led to the planting of beech as the main species, with lesser areas of western hemlock, Japanese larch, Lawson cypress, Douglas fir, *Thuja plicata*, and poplars. Growth so far is very satisfactory. Ten people are employed. China clay is mined nearby, using hydraulic processes.

Erme

Erme Forest lies 10 miles east of Plymouth, around Ermington in the valley of the Erme River. It consists of 641 acres, in ten small blocks, acquired since 1949. The land lies in steep valleys, and has on the whole fertile soils derived from a considerable variety of rocks, including Devonian shales, igneous strata, and alluvium. After clearance of the crops by previous owners, planting began in 1953. Beech is the main species, with lesser areas of Scots pine, Japanese larch, western hemlock, and Lawson cypress. All the plantations are growing well, except for one area with old mine workings, where mineral poisoning is suspected.

Dartmoor

Dartmoor

Dartmoor consists of an exposed granite tableland in the heart of South Devon forming many thousand acres of peaty moorland; the general elevation is around 1,500 feet, and the highest of the tors, or rocky summits, exceeds 2,000 feet. Much of the land is unenclosed grazing, shared by farmers who depasture cattle, sheep, and ponies. Both the moor and its surroundings now form a National Park. In 1932 the Forestry Commission acquired from the Duchy of Cornwall a large hill farm called Bellever, covering 1,200 acres; later acquisitions in 1932 and 1945 brought the total to 2,287 acres, in four large blocks with three small outliers, all within 4 miles of the main road from Moretonhampstead to Tavistock. Planting began at the Bellever block, west of Postbridge, in 1933; Sitka spruce was the

main tree used; there are smaller areas of Norway spruce, Japanese larch, and Douglas fir, all less successful than Sitka; occasional examples of lodgepole pine and Lawson cypress are promising. The peat land, which carried blue moor grass and heather, was ploughed before planting. Growth has been slow on exposed hills, up to 1,500 feet, and good in the sheltered valley of the River Dart and on the few old woodland sites. Many plantations are now at the thinning stage, and a good road system is being built. The Soussons block, east of Postbridge, is younger, dating from 1945; Sitka spruce is again the main species, and establishment is slow.

Nineteen people are employed, and to house them in this remote place, thirteen modern houses have been built at Bellever. Bellever Tor and Laughter Tor are local landmarks, and the area is rich in prehistoric stone circles, stone rows, and kistvaens or cremation chambers, dated to the Bronze Age. Rainfall averages 80 inches, and mists are frequent.

Fernworthy

Five miles south-west of Chagford, on the eastern fringe of Dartmoor, the Torquay Corporation has constructed a reservoir in a catchment area in which, in 1921, the Duchy of Cornwall had started afforestation primarily as a relief for unemployment. The plantations were transferred to the Forestry Commission in 1931, and further extended; including outlying blocks near Gidleigh, they now cover 1,505 acres. The bulk of the woods lies in three sheltered valleys, Lowton, Assycombe, and South Teign, which fall from open moors at 1,650 feet to the reservoir at 1,100 feet. Sitka spruce is the main and most successful species; there is some Norway spruce, Douglas fir, and western hemlock. Growth, particularly of Sitka spruce, has been exceptionally good and even. At 36 years many crops exceed 70 feet in height; thinning is done on a 3-year cycle, yielding stakes, pitprops, and considerable quantities of boxboard timber. Employment is provided for eighteen men, who are transported daily from Chagford by lorry. The soil is peaty, over granite gravel. A good road system has been put in.

North-east Devon

Eggesford

Shortly after its formation in 1919, the Forestry Commission acquired a group of cleared woodlands at Eggesford, in the Taw Valley midway between Exeter and Barnstaple, and close to the road and railway linking those towns. It was there that in 1919 the Forestry Commission's first trees were planted with appropriate ceremony; and there also that, in 1956, Her Majesty the Queen unveiled a tablet to record the planting, in that year, of one million acres by the Forestry Commission. The Eggesford woods now cover 1,207 acres; these are largely of Douglas fir, which has done well. Other species grown are spruces, larches, and *Abies grandis*, while there is some ash of natural origin. The best plantations are now receiving their fourth and fifth thinnings and yielding timber of boxwood dimensions. Fifteen people are employed. The geological formation is the Culm Measures.

This is aesthetically one of the most pleasing forests in the south-west; the well-grown woods on the steep hillsides are separated by good pasture, and the whole valley gives a satisfying impression of well being.

Molton Woods

Near the town of South Molton in North Devon there are a large number of small woods, situated for the most part in the steep-sided valleys of small streams that run south, down from Exmoor, to join the River Bray or the River Yeo. In 1954 the Forestry Commission began the acquisition of suitable areas—mainly old oak coppice—for replanting; Molton

Woods Forest now includes nineteen small blocks, with a total area of 800 acres. The surrounding country is pastoral in character; elevations range from 600 to 1,000 feet, and the geological formation is the Devonian. Douglas fir, beech, and Japanese larch figure largely in the replanting programme. Red deer are occasionally seen in these woods.

Six men are employed.

Bampton

Bampton Forest comprises 348 acres of oak woodland, acquired for replanting since 1956. It consists of two main blocks; one, Stuckeridge Wood, is in the Exe Valley 2 miles south-west of Bampton town. The valley sides are steep, in places almost precipitous, and the soil, a strong loam derived from the Culm Measures, is shallow on the south-facing slopes. There are several big quarries in the locality and it is possible that one may be developed right up to the forest boundary. This block has an imposing entrance through lodge-gates and over a chain suspension bridge across the River Exe.

The other block, Huntsham Wood, is 4 miles south-east of the town of Bampton near the west bank of the River Loman, a tributary of the Exe. Here the slopes are more gentle and the soil deeper and more fertile.

The main species to be planted will probably be Douglas fir, but the better soils of Huntsham will undoubtedly carry oak and beech in mixture with larch and other conifers.

South-east Devon

Haldon

Great Haldon Hill forms a plateau, some 6 miles long and 800 feet high, which runs from north to south a few miles west of Exeter, and is crossed by the main roads to Plymouth and Torquay. Its upper levels form a tableland of Eocene gravels, with a heathy vegetation. The slopes, on all sides and in the combes, show an exposure of Greensand, which gives place at the lower levels on the west to Culm slates, and on both sides, locally, to New Red Sandstone, whilst at the northern end an isolated block of basalt occurs. The slopes have long been wooded, though most woods were felled or derelict when acquired by the Forestry Commission. Operations began here in 1920, and altogether 3,874 acres have now been brought into Haldon Forest, through twenty-three separate acquisitions; the bulk forms one continuous woodland on the hill, but there are outliers near Powderham, Kingsteignton, and at Stoke Woods north of Exeter.

Remarkable contrasts in growth, related to prevailing soils, are now evident. On the hill tops, about 600 acres of heath were planted with Scots pine, using mattocks and without any ploughing; the gravels here are cemented with a stiff grey clay, and topped by a layer of brown fibrous peat, but little pan is apparent. Growth has been astonishingly poor, many pines remaining as worthless bushes only a few feet high, after 35 years existence. Trial plots were made in 1957 by the Research Branch to find methods of rehabilitation; methods under test include clearance, followed by deep cultivation, and the application of phosphates; of several species tried, lodgepole pine and Lawson cypress have made the best start.

On old woodland sites farther down the slopes, the downwash soils of all the geological formations found have given very satisfactory crops of most species tried. These include Sitka and Norway spruces, Douglas fir, Japanese larch, and beech; one stand of 17-year-old Lawson cypress at Mamhead Bottom is exceptionally good. The forest as a whole is now a highly productive one, yielding some 150,000 hoppus feet a year from thinnings, including much material of boxwood size. Thirty-eight people are employed, and a good road system has been developed. Fire risk is high, owing to the enormous number of people using the

main roads, or visiting the hill to enjoy views of the coast and Dartmoor. The Racecourse, almost entirely surrounded by highly inflammable plantations, is a particular source of danger, for which some measure of compensation is gained by permission to use the top of the grandstand as a fire tower.

Honiton

The country around Honiton town consists of an intricate series of valleys between hills running up to 950 feet elevation. The ridges are capped with remarkable Cretaceous gravels, called the Chert Beds, which support only a heathy vegetation, while on their slopes there is often an exposure of Greensand, too steep and poor for even pastoral farming. Hence there arises a discontinuous pattern of waste and woodland amid rich agricultural country. Amongst this, the Forestry Commission has, since 1952, built up a forest of 1,287 acres, by eleven acquisitions spread over as many blocks. The gravel hilltops have been ploughed and planted with Scots and Corsican pines. On the Greensand, ploughing is done where the slope and vegetation permit; drainage is needed in peaty hollows; a partial clearance of scrub is needed locally.

A wide range of species is used here, each being chosen in accordance with variations in site and vegetation; beech and Douglas fir figure largely, with Japanese larch, hemlock, *Abies grandis*, and spruces on a lesser scale. Nineteen men are employed. Amenity is a major consideration, particularly near noted viewpoints, such as East Hill above Ottery St. Mary.

North-west Somerset

Dunster

In 1952 the Forestry Commission took over from the Commissioners of Crown Lands some of the woodland portions of the Dunster Estate; these comprise most of Dunster Forest's 2,022 acres, and adjoin the older-established Brendon Forest. The land lies on the high ground, or in the deep combes of the Brendon Hills, south of Dunster. About 1,200 acres were bare ground, mostly felled woodland, when taken over; their replanting, mainly with Corsican pine and Sitka spruce, has proceeded steadily since; wherever possible the ground is ploughed.

The balance of 800 acres includes several noteworthy stands established by the former owners, the Luttrell family, during the past century. At Langridge Wood, near Roadwater, there are exceptional plantations of western hemlock, *Abies grandis*, and *Thuja plicata*; all three species here regenerate naturally. There is also an interesting small group of *Sequoia sempervirens*. A Sitka spruce stand nearby is ranked as 'Super Quality I'. Broadwood, near Timberscombe, holds a few fine Douglas fir; one specimen tree, planted in 1874, scaled 150 feet with a girth of 13 feet 2 inches in 1956. The main rock formations at Dunster are the Devonian Old Red Sandstones. Twenty-six men are employed.

Brendon

Brendon Forest lies adjacent to Dunster Forest and runs from the outskirts of Dunster town to the sandstone ridge of the Brendon Hills, with outliers farther south. Its total extent is 2,817 acres, in ten separate blocks, acquired between 1920 and 1957. The oldest and most prominent portion is Croydon Hill, occupying nearly 900 acres on a ridge, rising to a height of 1,250 feet, facing the Bristol Channel. Here, on former moorland, Sitka spruce and Scots pine have given a fair performance, and are now at the thinning stage. European larch is less satisfactory, while Corsican pine, after making a good start, is now giving grounds for some doubt at the higher elevations. On the lower south-facing slopes of Monkham Hill, Douglas fir is growing well though less rapidly than in the valley bottoms.

Farther south, the Kennisham Hill and Chargot Wood portions run up to the Brendon ridge, touching 1,300 feet; growth is fair on former moors, but good in the shelter of the combes, most of which once carried oak coppice. The outliers are mostly old woods or coppices requiring replanting; local conditions of soil and shelter promise satisfactory growth. Twenty-six people are employed, though much thinning is done by merchants. There is a fire tower on Croydon Hill. Iron ore was formerly mined around Kennisham Hill; the geological formations are Devonian and Old Red Sandstone.

Quantock

The Quantock Hills form a well-defined range with a general elevation of 1,000 feet, running south-east from the Bristol Channel for 15 miles towards Taunton and Bridgwater; their average width is 5 miles. Their bedrocks are Old Red Sandstone and Devonian, and they are broken up irregularly by numerous valleys or combes, most of which run down towards the north-east, and so provide shelter. Some of the land forms small pastoral farms, but much is an open waste of bracken, heath, and derelict oak coppice, once worked for tanbark. The Quantock Forest now extends to 2,766 acres, and includes five large and three small areas. The main block, near Over Stowey, accounts for 1,540 acres, extending over five combes, and was acquired in 1927. It is remarkable for the excellent growth of Sitka spruce and Douglas fir which, though barely 30 years old, already give the impression of mature forest. They have been thinned several times, and a good new road system facilitates extraction of produce. European larch has given very poor results; Japanese larch is, however, promising. Corsican pine thrives at first, but tends to die back at the highest levels, after 25 years growth; Scots pine gives fair results.

The St. Audries portion, near the sea at the north of the range, shows similar results to the main block, but maritime exposure has severely depressed the growth of European larch, and its replacement is an immediate problem.

Kinder conditions obtain at the remaining portions, which lie south-east of the main block, towards Bridgwater. Here old hardwoods, chiefly oak and ash, are being maintained, and much beech planted, as well as conifers. Kingscliff Wood, 2 miles south-west of North Petherton, holds in its long narrow valley a noteworthy series of poplar varietal trials, organized by the Forestry Commission's Research Branch; over eighty strains, including white, aspen, black, balsam, and hybrid poplars, are represented. A small plot of *Populus* 'Androscoggin', planted in 1950, was 50 feet tall in 1957, having averaged 6 feet of growth each season.

A fire tower has been built on the main block. Thinnings are currently done by merchants, on a long-term contract, but eighteen people are also directly employed.

Noteworthy features of the woods as a whole include the presence of wild red deer, which are hunted locally; buzzards are also common.

South Somerset

Neroche

South of Taunton and on the northern slopes of the Black Down Hills, which divide Somerset from Devon, there is a stretch of wild hilly country which in medieval times formed the Forest of Neroche. One of its highest points, giving a magnificent view over Sedgemoor, carries remains of a prehistoric fortress called Castle Neroche. The main geological formation is the Lower Greensand, which here gives much ground too steep for farming; on the summits, around 1,000 feet elevation, it is topped by infertile gravels; on low ground towards the north it is replaced by heavy Lias clays and Keuper marls. After the 1939–45 war a large expanse of felled woodland and coppice, together with some rough

waste land, was secured from the Portman Estates by the Commissioners of Crown Lands, who leased it to the Forestry Commission. Together with later acquisitions, this makes up the modern Neroche Forest of 2,445 acres.

Replanting has progressed steadily, with a variety of species and methods to suit marked variations in sites. Gravel hilltops are ploughed and planted with pines and spruces. Bare greensand slopes are ploughed where possible, and put under more exacting species, including beech, oak, red oak, Japanese larch, and Lawson cypress; amenity considerations have here favoured the use of numerous species in irregular blocks. Scrub, particularly on heavy clays, is being thinned out for underplanting with beech and Norway spruce. With the exception of some of the oak, growth is everywhere satisfactory. Seventeen people are employed. A peat bog on Britty Common is scheduled by the Nature Conservancy as a site of particular botanic interest.

Sedgemoor

Around Langport and Somerton, amid the flat, artificially drained land of the old Sedgemoor marshes, some of the higher ground on the Lias and Keuper formations carries woodland. Since 1946 the Commission has acquired 431 acres which lie in two blocks—Breech north of Langport and Copley north of Somerton. Six people are employed. Elevations run from 250 to 350 feet.

About half of Breech Wood was former agricultural land of not very high productivity, but was leased to the Forestry Commission for afforestation by the Somerset Territorial Association because it lies in the danger area behind their rifle range. Scots pine (47 acres) and Corsican pine (12 acres) have been used with some beech on the former agricultural land.

Copley Wood carried a full stock of ash poles but on the shallow dry soil there was no chance of this developing into useful timber. It was therefore opened up to leave a light cover beneath which beech (161 acres) was planted.

Bruton

Bruton Forest lies in the east of Somerset, between Frome and Bruton, on land that formed part of the medieval forest of Selwood. The older portions of it, which extend to 638 acres and were acquired in 1929, are situated on the Upper Greensand, which here forms a conspicuous ridge, 900 feet high, along the Wiltshire–Somerset boundary. King Alfred's Tower, the property of the National Trust, a modern memorial of a battle with the invading Danes in A.D. 879, commands a magnificent view west over Sedgemoor, and is incidentally used as the forest fire tower. The older woods, planted between 1930 and 1940, lie on Greensand slopes with a north-western aspect, and are remarkable for their rapid and uniform growth. Virtually all species tried have succeeded, the main one is Douglas fir, with lesser areas of spruces, larches, and beech, some oak and *Abies grandis*. Several of these plantations have been thinned two or three times; Japanese larch may here require thinning when only 10 years old. One beech plantation is of particular interest as it contains a mixture of red oak (*Quercus borealis*) and sycamore (*Acer pseudoplatanus*). Although the beech are growing rapidly the red oak and sycamore are growing even more rapidly and are of good form having escaped, so far, serious attacks from grey squirrels.

Since 1946, woods of a different character have been incorporated in Bruton Forest through the addition of eleven blocks of felled woodland scattered around Witham Friary village. The geological formations here are the Oxford Clay and the Great Oolite, and their fertile soils have a reputation for growing oak of first quality. Oak has therefore been the main tree planted, with very good results so far, even where directly sown. Norway spruce

has been used locally to give intermediate yields, and there are small areas of ash and beech. Sixteen people are directly employed at Bruton Forest, and others work for timber merchants who purchase the thinnings standing. The total area is 1,035 acres.

North-east Somerset

Mendip and Shepton

The Mendip Hills, in North Somerset, form a narrow range which is situated about 15 miles south of Bristol, and runs for 30 miles from north-west to south-east. Their average width is 6 miles and their average height around 800 feet, though they touch 1,050 feet in places. The main geological formation is the Carboniferous Limestone, but there are also outcrops of Coal Measures, Old Red Sandstone, Lias, and volcanic rocks. On the plateau, where most of the woods lie, the soils are deep and unleached. In the past there were extensive workings for lead ores. Most of the land is pasture, but there are broad stretches of rough grazing carrying a vegetation of dwarf gorse, heather, bell heather, and bracken. Three stretches of such ground, some of which have been worked over for lead, totalling 1,223 acres have been acquired to form Mendip Forest in the north-west and centre, while three former woodlands covering 160 acres in the south-west, near Shepton Mallet, comprise Shepton Forest; the first acquisitions were made in 1940 and planting was completed by 1957.

Though good broadleaved woodland grows on the northern sheltered slopes of the Mendips, the high degree of exposure and the moorland vegetation of Mendip Forest indicated coniferous crops; but few pointers were available locally to the appropriate choice of species. Main reliance has been placed on Sitka spruce, which has done reasonably well; smaller areas have been planted with Norway spruce, Scots pine, Corsican pine, and Japanese larch, with a good deal of beech, usually with a conifer nurse, on the better more sheltered ground. So far all species are thriving, but the forest has suffered setbacks from somewhat exceptional causes. The Rowberrow portion of Mendip, at the north-east, is bordered by commons that are frequently set on fire; in May 1956 one such fire crossed the border and destroyed 197 acres of thriving Sitka spruce, out of 544 acres in the block. At the central Mendip area, near Priddy, some 300 out of 478 acres are situated on old lead workings, and toxic symptoms are apparent on trees around 15 years old; all species are affected, and irregular losses have resulted in an uneven crop; it is too early to say whether they will grow out of their present disturbing phase.

At the Harptree portion on the sheltered northern face, growth is so far satisfactory, even around an old lead works. There is a small nursery at Mendip.

At Shepton Forest, which is situated on Old Red Sandstone around Cranmore Tower, a local landmark, beech is the main species planted, usually with a coniferous nurse. Despite considerable exposure growth on the old woodland soils has been good.

Stokeleigh

This is a small forest of 639 acres, situated on the Carboniferous Limestone hills just to the west of Bristol. One portion lies on the steep slopes of the Avon Gorge, near the Clifton Suspension Bridge, and when acquired in 1949, after war-time fellings, carried a mixed scrub and coppice of hazel, lime, hornbeam, ash, oak, sycamore, birch, guelder rose, briars, and holly. This is gradually being thinned out, or clear cut, by a small labour force, to allow of the planting of beech, red oak, and Japanese larch; as the wood has high amenity value, care is being taken to avoid large clearings. The rest of the forest consists mainly of pole stage plantations of ash, sycamore, and Corsican pine, with some sweet chestnut and yew,

aged from 40 to 60 years, which were acquired as standing crops; they lie on south-facing slopes above Long Ashton.

ACKNOWLEDGEMENT

We wish to acknowledge the generous assistance given by colleagues in the Forestry Commission Research Branch and in the South-West Conservancy.

TWO EXAMINATIONS IN ARBORICULTURE

IN a note in the recent Commemoration number of the *Quarterly Journal of Forestry*, Mr. N. D. G. James discusses the great *potential* interest that exists in ornamental and specimen trees not only amongst individuals but amongst local authorities, development corporations, planning authorities, public parks and cemeteries, and schools and educational authorities, and points out the opportunity and indeed need for the Royal Forestry Society of England and Wales to encourage and foster this interest; to supply information; and to get more men trained in arboricultural practice. The Society has recognized this by establishing in 1957 within the Society an arboricultural section and by setting up two examinations in arboriculture some details of which, taken from the regulations and syllabus now issued by the Society, are given below.

There will be two examinations each with a written part and a practical and oral part for (i) a certificate, and (ii) a diploma. Normally the examinations will be held in June and applications to sit for either examination must be made to the Secretary of the Society at 49 Russell Square on a form to be returned by 31st December. A candidate for the diploma must produce evidence of having obtained the certificate. Examination fees are two guineas and four guineas respectively. Candidates must be 18 years of age or over but there seem to be no other qualifications required. The regulations give the syllabus for each examination and a list of books recommended for study.

THE BRITISH ASSOCIATION, DUBLIN, 1957

THE Forestry Sub-Section held a very successful meeting in Dublin from 4th to 11th September under the Chairmanship of Mr. T. McEvoy, Department of Lands. His address was entitled 'Forestry in Ireland'. The following is an outline of the programme:

Friday, 6th Sept.

Ecology of peat and peat afforestation (Joint session with Botany Section).
Rev. J. J. Moore, S.J. 'Survey of Irish Boglands.'
Mr. M. E. S. Morrison. 'The ecology of a raised bog in County Tyrone.'
Mr. K. F. Parkin. 'Afforestation of peatlands in Northern Ireland.'
Mr. R. E. Parker. 'Ecological problems arising in the afforestation of peat land.'
Excursion to Irish Timber Industries, Ltd.

Saturday, 7th Sept.

Excursion to Shelton Abbey Forestry School and Avondale Forestry Centre.

Sunday, 8th Sept.

Excursion to Avoca and Glenealy Forest.

Monday, 9th Sept.

Forest Management and silviculture in underdeveloped areas.
Dr. F. C. Hummel. 'Yield regulation and forecasts of production.'
Mr. D. A. Francis. 'Aerial photography and forestry.'
Mr. T. Clear. 'Some experiences in the survey and assessment of growing stock for forest management purposes.'
Excursion to the Clondalkin Paper Mills.

Tuesday, 10th Sept.

Economics of Forestry, and other subjects.
Mr. W. E. Hiley. 'Economics in Forest Management.'
Mr. E. R. Huggard. 'Roads for economic timber extraction.'
Mr. O. V. Mooney. 'Pinus contorta.'
Excursion to Delgany Forest, Co. Wicklow.

During the meeting, the Department of Lands staged a most impressive Exhibition on Forestry in Ireland.

T. H. O.

THE MAXIMUM MOISTURE CONTENT OF WOOD

By R. F. S. HEARMON and J. M. PATON

(*Forest Products Research Laboratory, Princes Risborough*)

SUMMARY

The maximum moisture contents of seventeen timbers have been determined and compared with calculated values, assuming a density of 1·5 g. per c.c. for the wood substance. The converse approach, in which the maximum moisture contents are used to determine basic densities is also discussed. With the present set of timbers, basic density can usually be estimated to within about 1 or 2 per cent., and with the aid of an empirical relationship between basic and dry densities, the latter can usually be estimated to within 3 or 4 per cent. Although most of the timbers attained their maximum moisture content within a few days, exceptional timbers may require a period of several weeks or even months before the absorption of water is complete.

INTRODUCTION

THE maximum amount of water (or other liquid) which wood can hold is of interest in connexion with the immersion of logs, with moisture in the living tree (Chalk and Bigg, 1956), and with wood preservation and seasoning. Keylwerth (1954) has shown that the 'basic density' of wood can be estimated from the maximum moisture content, without making any volume measurements, and this technique has been further developed by Smith (1954 and 1955*a*).

In a completely saturated block of wood of volume V_1, the two constituents are wood substance (volume V_2) and water (volume V_3). Thus

$$V_1 = V_2 + V_3.$$

Assuming (*a*) that the density of the wood substance is 1·5 g. per c.c. (Kollmann, 1951) and (*b*) that the density of the water is 1 g. per c.c., then

$$V_3 = V_1 - w/1{\cdot}5, \tag{1}$$

and

$$m = \frac{V_3}{w} = \frac{V_1}{w} - \frac{1}{1{\cdot}5} = \frac{1}{R} - \frac{1}{1{\cdot}5}, \tag{2}$$

where w is the dry weight of the wood,
m is the maximum moisture content (g./g.),
R is 'basic density' (dry weight g./saturated volume c.c.).

Assumption (*a*) means that the small variations in the density of wood substance from one wood to another (Kollmann, 1951), and also the variations in observed density encountered with different displacement liquids (Kelsey, 1955), are ignored; assumption (*b*) means that the effects of sorption compression (Stamm and Hansen, 1937) are also ignored.

If the additional assumptions are made: (*c*) that the 'fibre saturation point' is 28 per cent.; (*d*) that up to this point the increase in volume of the aggregate is equal to the volume of water adsorbed; and (*e*) that there is no further change

in volume above 28 per cent. moisture content, then the maximum water uptake can be expressed in terms of 'dry density' r (dry weight g./dry volume c.c.), as follows:

$$V_1 = 0{\cdot}28w + V_4, \tag{3}$$

where V_4 is the dry volume. Thus substituting (3) in (1)

$$V_3 = 0{\cdot}28w + V_4 - \frac{w}{1{\cdot}5},$$

and

$$m = \frac{V_3}{w} = 0{\cdot}28 + \frac{V_4}{w} - \frac{1}{1{\cdot}5} = \frac{1}{r} - 0{\cdot}387. \tag{4}$$

Equations (2) and (4) are the same as those given by Kollmann (1951) and further discussed by Gonet (1956).

EXPERIMENTAL

Equation (2) has been verified by Keylwerth (1954) on a single species, Douglas fir, over the range of R from 0·28 to 0·56. The present work was undertaken to extend the comparison between observed and calculated m to a number of species of widely varying densities.

The timbers tested were the following:

Quipo (*Cavanillesia platanifolia*)
Balsa (*Ochroma lagopus*)
Sitka spruce (*Picea sitchensis*)
Western red cedar (*Thuja plicata*)
Gaboon (*Aucoumea klaineana*)
Cypress (*Cupressus* sp.)
Douglas fir (*Pseudotsuga taxifolia*)
Sycamore (*Acer pseudoplatanus*)
Ash (*Fraxinus excelsior*)
Larch (*Larix decidua*)
Beech (*Fagus sylvatica*)
Maracaibo boxwood (*Gossypiospermum praecox*)
Serrette (*Byrsonima spicata*)
Oak (*Quercus petraea* or *Q. robur*)
Wallaba (*Eperua falcata*)
Muhimbi (*Cynometra alexandri*)
Ekki (*Lophira alata*)

Samples of these seventeen species ranging in dry density from 0·12 (quipo) to 1·06 (ekki) were obtained. From these, test specimens were machined to dimensions of 10 × 2 × 0·5 cm. in the longitudinal, radial, and tangential directions respectively. Two test specimens from each of the seventeen species were dried over phosphorus pentoxide in a vacuum desiccator to constant weight. When constant weight had been attained, each pair of specimens was stored in a dry 6 in. × 1 in. test-tube closed with a rubber stopper. Using a dial gauge reading to 0·001 cm., the dimensions of each of the specimens were accurately measured. The specimens were then stacked in a large flat-bottomed crystallizing dish, using lengths of 3-mm. glass rod as spacers. A number of glass weights filled with lead shot were placed on top of the stack, and the crystallizing dish with its contents transferred to a large vacuum desiccator, having the usual stopcock replaced by a 4-limbed glass fitting, one limb leading into the desiccator through a rubber stopper. Clear colourless plastic tubing was attached to each of the three remaining limbs of the 4-way fitting, and these could be opened or closed by means of large screw clips, A, B, and C (see Fig. 1). The free end of the tube carrying B was inserted into a flask of previously boiled water, and the latter sucked into the tubing so as just to reach the clip B. With B and C closed, the desiccator was

evacuated with a rotary pump for about 3 hours. Clip A was then closed and B carefully opened so that water was drawn from the flask into the crystallizing dish, B being closed when the volume of the water above the specimens was well in excess of the volume of the latter. Finally, C was opened to admit air and thus to apply a positive pressure, and the whole assembly was then allowed to stand overnight (about 16 hours).

After wiping the surfaces with a damp cloth to remove excess water, each

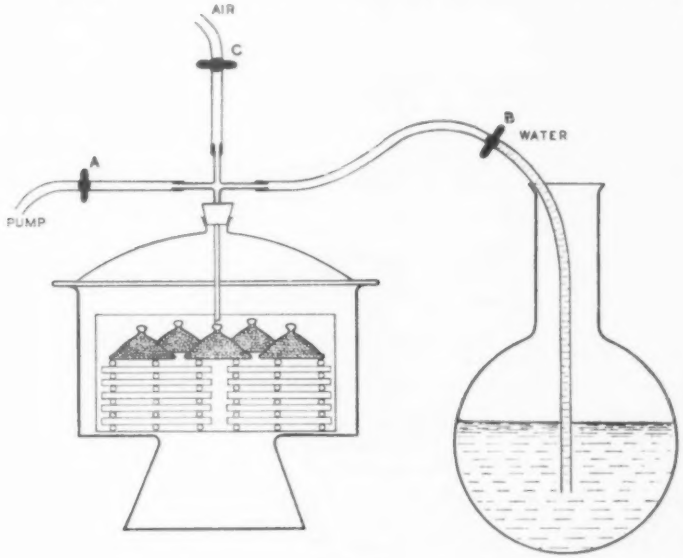

FIG. 1

specimen was quickly weighed and duplicate pairs were stored in water in the 6 in. × 1 in. test-tubes pending measurement of the wet dimensions of the specimens with the dial gauge. After taking these measurements, the specimens were returned to the tubes and left immersed for 1 year, when the measurements were repeated.

RESULTS AND DISCUSSION

1. *General*

The results are given in cols. 1–4 of Table I. Comparing cols. 3 and 4, it is evident that all of the timbers took up more water on continued immersion after 16 hours, and this process was particularly marked in gaboon. The classifications of the timbers as heartwood and sapwood in Table I are all somewhat tentative and any especially doubtful ones are indicated by a question-mark. There does not seem to be any clear-cut relation between rate of moisture uptake and sapwood or heartwood content, but the timber with the slowest uptake, gaboon, was almost certainly heartwood. The observed and calculated moisture contents are

TABLE I. *Comparison of observed and calculated moisture contents (m) and densities (R and r)*

Species (H = Heartwood, S = Sapwood)	(1) Dry wt./ Dry vol. (g./c.c.) = r (obs.)	(2) Dry wt./ Wet vol. (g./c.c.) = R (obs.)	(3) Observed moisture content (g./g.) 16 hrs.	(4) 1 year = m	(5) $\frac{m}{eqn.\ (2)}$	(6) $\frac{m}{eqn.\ (4)}$	(7) $\frac{m}{eqn.\ (7)}$	(8) $\frac{1}{m+0{\cdot}667} = R_e$	(9) $\frac{R}{R_e}$	(10) $1{\cdot}171\ R_e = r_e$	(11) $\frac{r}{r_e}$
Quipo (S?)	0·118	0·108	8·49	8·89	1·04	1·10	0·96	0·105	1·03	0·123	0·96
	0·121	0·110	7·75	8·85	1·05	1·12	0·98	0·105	1·05	0·123	0·98
Balsa (S?)	0·203	0·180	4·67	4·95	1·01	1·09	0·97	0·178	1·01	0·208	0·98
	0·267	0·241	3·36	3·51	1·01	1·05	0·94	0·239	1·01	0·280	0·95
Sitka spruce (S?)	0·329	0·292	2·77	2·89	1·05	1·09	1·00	0·281	1·04	0·329	1·00
	0·332	0·293	2·59	2·81	1·03	1·07	0·98	0·287	1·02	0·336	0·99
Western red cedar (S)	0·333	0·302	2·10	2·63	1·00	1·01	0·92	0·303	1·00	0·355	0·94
	0·333	0·301	2·10	2·64	1·00	1·01	0·93	0·302	1·00	0·354	0·94
Gaboon (H)	0·351	0·317	0·71	2·53	1·02	1·03	0·95	0·312	1·02	0·365	0·96
	0·380	0·347	0·63	2·20	1·00	0·98	0·91	0·348	1·00	0·407	0·93
Cypress (HS)	0·431	0·369	2·00	2·05	1·00	1·06	1·00	0·368	1·00	0·431	1·00
	0·432	0·363	2·00	2·06	0·99	1·07	1·01	0·366	0·99	0·429	1·01
Douglas fir (S)	0·568	0·491	1·25	1·38	1·01	1·01	0·99	0·488	1·01	0·571	0·99
	0·529	0·462	1·40	1·51	1·01	1·01	0·98	0·459	1·01	0·538	0·98
Sycamore (?)	0·589	0·503	1·24	1·32	1·00	1·01	1·00	0·502	1·00	0·588	1·00
	0·591	0·505	1·24	1·32	1·01	1·02	1·01	0·502	1·01	0·588	1·00
Ash (?)	0·593	0·495	1·23	1·36	1·01	1·05	1·05	0·493	1·00	0·577	1·03
	0·590	0·493	1·24	1·37	1·01	1·05	1·05	0·490	1·01	0·574	1·03
Larch (H)	0·610	0·545	1·06	1·16	1·00	0·93	0·93	0·546	1·00	0·639	0·95
	0·603	0·529	1·17	1·24	1·02	0·98	0·98	0·524	1·01	0·614	0·98
Beech (?)	0·672	0·555	1·03	1·15	1·02	1·05	1·07	0·549	1·01	0·643	1·04
	0·684	0·558	1·05	1·13	1·01	1·06	1·09	0·536	1·00	0·651	1·05
Maracaibo boxwood (S?)	0·695	0·609	0·96	0·970	1·00	0·92	0·96	0·616	0·99	0·721	0·96
	0·712	0·623	0·85	0·939	1·01	0·93	0·96	0·627	0·99	0·734	0·97
Serrette (S?)	0·759	0·639	0·69	0·893	0·99	0·96	1·02	0·641	1·00	0·751	1·01
	0·741	0·632	0·70	0·905	0·99	0·94	0·99	0·638	0·99	0·747	0·99
Oak (H)	0·778	0·633	0·64	0·923	1·01	1·03	1·10	0·629	1·01	0·737	1·06
	0·768	0·629	0·65	0·939	1·02	1·03	1·10	0·627	1·00	0·734	1·05
Wallaba (H)	0·909	0·800	0·32	0·578	0·99	0·81	0·93	0·803	1·00	0·940	0·97
	0·948	0·831	0·30	0·533	0·99	0·80	0·94	0·833	1·00	0·975	0·97
Muhimbi (S)	0·960	0·806	0·45	0·571	0·99	0·87	1·03	0·808	1·00	0·946	1·01
	0·937	0·788	0·50	0·588	0·98	0·86	1·01	0·797	0·99	0·933	1·00
Ekki (H)	1·057	0·857	0·37	0·471	0·94	0·84	1·07	0·879	0·98	1·029	1·03
	1·061	0·868	0·35	0·459	0·95	0·83	1·05	0·888	0·98	1·040	1·02
Mean	0·588	0·502	..	..	1·005	0·990	0·996	..	1·005	..	0·992
P. e.	..	..	..	..	2·2	8·9	5·3	..	1·5	..	3·4

plotted against R (col. 2, Table I) in Fig. 2, which shows that the observed moisture contents after 1 year are in excellent agreement with those calculated from equation (2). This agreement is also brought out by col. 5, Table I, which gives the ratio (m observed/m calculated from (2)). The mean ratio (shown at the

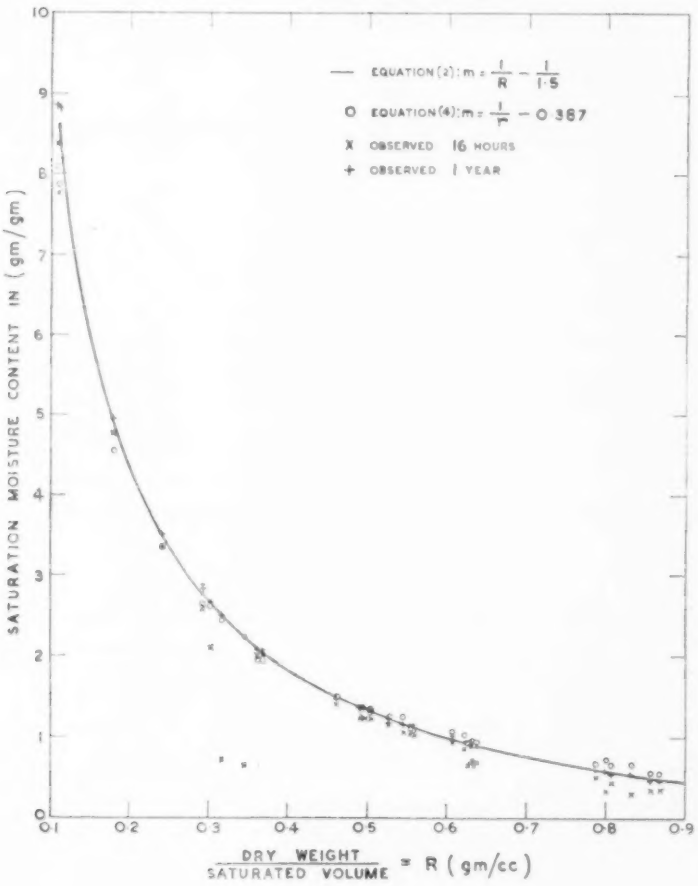

FIG. 2

bottom of the column) is 1·005 and the coefficient of variation ($V = 100 \times$ standard deviation/mean) is 2·2 per cent. Thus, to sufficient accuracy, the assumptions (*a*) and (*b*) made in deriving equation (2) hold for the present set of timbers.

2. *Calculation of maximum moisture content from dry density r*

Since the dry density r may be more readily available than the basic density R, it is of interest to examine the accuracy with which m can be calculated from r.

Fig. 2 shows that equation (4) tends to give too low values at low density and too high values at high density. Col. 6, Table I, lists the corresponding ratios; the mean ratio is 0·990 and the coefficient of variation 8·9 per cent. Equation (4) as it stands is thus of rather low accuracy, and is possibly capable of improvement.

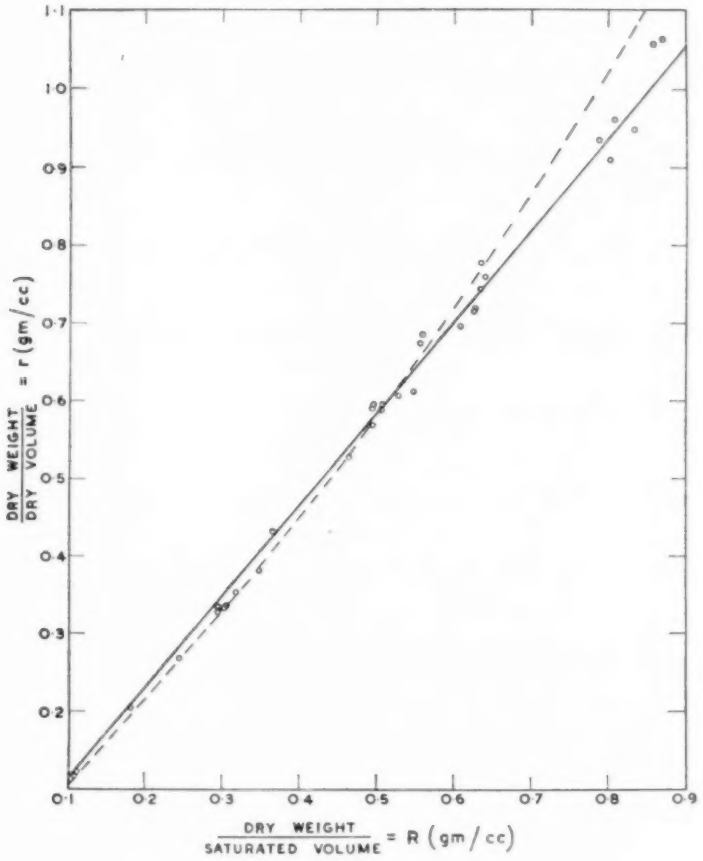

FIG. 3

Gonet (1956) has pointed out in effect that equating equations (2) and (4) leads to the relation

$$\frac{1}{R} = 0{\cdot}28 + \frac{1}{r},$$

or

$$R = \frac{r}{1 + 0{\cdot}28r}. \qquad (5)$$

In Fig. 3 the observed values of r and R are plotted one against the other. The

relationship (5) is shown by the broken line and it is apparent that the line deviates from the observations at higher densities. The continuous straight line has been drawn to pass through the origin and the mean values of r and R, and fits the observed values better than the broken line. It is not a true regression line, but has been chosen because it fits the observations reasonably well, and it avoids the occurrence of additive constants in the relationship between r and R. The relationship found in this way is

$$R = 0{\cdot}854r \tag{6}$$

and substituting equation (6) in (2) leads to

$$m = \frac{1{\cdot}171}{r} - \frac{1}{1{\cdot}5}. \tag{7}$$

This equation is subject to the assumptions (*a*) and (*b*), p. 53, and the additional empirical assumption that equation (6) is the true relationship between R and r.

Values of (m observed/m calculated from (7)) are given in col. 7, Table I. The mean value is rather nearer unity than the corresponding mean of col. 6, and the coefficient of variation is smaller, but not as small as that of col. 5. Thus equation (7) is rather better than (4), but not so good as (2). In view of the scatter of the points in Fig. 2, it is perhaps doubtful whether any further improvement on equation (7) is possible.

3. *Determination of basic density R*

Keylwerth (1954) pointed out that equation (2) can be transformed to

$$R = \frac{1}{m+0{\cdot}667}, \tag{8}$$

and measurement of m therefore enables R to be obtained without making any volume measurements. Keylwerth used the method in an analysis of increment in Douglas fir; Smith (1954) has further discussed the method and found that 4–5 days were required with green loblolly pine specimens for the maximum amount of water to be taken up. Later (1955*a*) she found that 7–10 days were necessary with Douglas fir for complete saturation, and compared the maximum m method with the water immersion method. The latter gave results up to about 1 per cent. higher and these differences were discussed in terms of the possible errors, including those due to uncertainty in the value for the density of wood substance. In her work, since extended (1955*b* and 1956) to studying the relation between specific gravity and percentage of summerwood in Douglas fir, Smith assumed a value of 1·53 for the density of wood substance, but pointed out that a given deviation from this value would produce a rather smaller deviation in the value of R calculated from equation (8).

The basic densities calculated from (8) using the observed values of m are given in col. 8, Table I, and col. 9 lists the ratios (observed density/calculated density). The mean ratio is 1·005 and V is 1·5 per cent. The fact that the mean ratio is rather greater than unity means that the overall agreement could be improved by taking a rather higher density than 1·5 for the wood substance, but the departures

TABLE II. *Moisture contents (g. water/g. dry wood) after various times, and comparison of observed and calculated densities. (Specimens are not the same as those in Table I)*

Species	*Time*	(1) 16 *hrs.*	(2) 45 *hrs.*	(3) 6 *days*	(4) 19 *days*	(5) 51 *days*	(6) $\frac{1}{m+0{\cdot}667} = R_e$	(7) R (*obs.*)	(8) $\frac{R}{R_e}$
Quipo		8·67	8·69	8·71	8·74	8·67	0·107	0·106	0·99
		8·72	8·72	8·72	8·79	8·71	0·107	0·105	0·98
Balsa		3·42	3·42	3·42	3·43	3·42	0·244	0·238	0·98
		4·38	4·36	4·39	4·45	4·45	0·195	0·193	0·99
Sitka spruce		2·89	2·90	2·91	2·92	2·92	0·279	0·277	0·99
		2·92	2·93	2·94	2·95	2·95	0·276	0·274	0·99
Western red cedar		2·30	2·65	2·73	2·75	2·76	0·291	0·291	1·00
		2·65	2·85	2·91	2·93	2·94	0·277	0·277	1·00
Gaboon		0·783	1·02	1·46	1·87	2·07	(0·365)	(0·328)	(0·90)
		0·794	1·02	1·46	1·88	2·09	(0·362)	(0·323)	(0·89)
Cypress		2·13	2·13	2·13	2·13	2·13	0·357	0·357	1·00
		2·07	2·08	2·08	2·09	2·08	0·364	0·365	1·00
Douglas fir		1·28	1·32	1·29	1·29	1·34	0·498	0·493	0·99
		1·46	1·47	1·45	1·45	1·49	0·463	0·460	0·99
Sycamore		1·29	1·29	1·30	1·30	1·30	0·508	0·501	0·99
		1·31	1·31	1·31	1·31	1·31	0·505	0·501	0·99
Ash		1·34	1·35	1·32	1·33	1·33	0·500	0·486	0·97
		1·27	1·28	1·25	1·25	1·25	0·521	0·501	0·96
Larch		1·25	1·26	1·27	1·25	1·26	0·518	0·507	0·98
		1·13	1·17	1·18	1·17	1·18	0·541	0·536	0·99
Beech		1·11	1·12	1·11	1·13	1·13	0·556	0·547	0·98
		1·12	1·12	1·12	1·13	1·13	0·556	0·556	1·00
Maracaibo boxwood		0·943	0·941	0·940	0·943	0·940	0·622	0·621	1·00
		0·957	0·954	0·950	0·953	0·954	0·617	0·614	1·00
Serrette		0·816	0·825	0·829	0·844	0·850	0·659	0·647	0·98
		0·840	0·846	0·849	0·866	0·877	0·648	0·636	0·98
Oak		0·681	0·667	0·874	0·907	0·916	0·633	0·622	0·98
		0·669	0·650	0·856	0·888	0·899	0·638	0·621	0·97
Wallaba		0·341	0·422	0·501	0·553	0·565	0·812	0·801	0·99
		0·305	0·383	0·455	0·507	0·523	0·840	0·832	0·99
Muhimbi		0·544	0·563	0·561	0·572	0·580	0·802	0·781	0·97
		0·548	0·564	0·561	0·572	0·582	0·801	0·787	0·98
Ekki		0·389	0·425	0·433	0·445	0·479	0·873	0·835	0·96
		0·383	0·421	0·426	0·442	0·475	0·876	0·840	0·96

of the ratios in col. 9 from unity are small, and if an accuracy better than about 1 per cent. were required for the basic density, it would probably be necessary to determine a value for the density of wood substance on the species actually under investigation.

When R has been found, an estimate of r can be found from equation (6) as

$$r = 1{\cdot}171R. \qquad (9)$$

Values of r calculated from equation (9) are given in col. 10, Table I, and the ratios (observed r/calculated r) in col. 11. The mean ratio is 0·992 and V is 3·4 per cent. Thus it is possible to calculate R to about 1 per cent. and r to about 3 per cent. from the results of waterlogging experiments. The larger uncertainty in r is not unexpected in view of the scatter of the points in Fig. 3 about the straight line (6); furthermore the scatter suggests that if the experiments were repeated with other timbers, a somewhat different equation connecting R and r could be obtained if the set of timbers used in the present experiments were not representative of timbers as a whole.

MOISTURE CONTENT AS AFFECTED BY TIME OF IMMERSION

After the main experiment described above had been completed a subsidiary experiment was carried out on a new set of specimens. Exactly the same procedure was followed, but the specimens were removed from the water and weighed after immersion for 16 and 45 hours, and 6, 19, and 51 days. The results are given in cols. 1–5, Table II; most of the timbers had reached a reasonably steady moisture content after 45 hours, but gaboon was still increasing very noticeably even after 51 days. The five heaviest timbers—serrette, oak, wallaba, muhimbi, and ekki—were also increasing, though less markedly than gaboon. The results of this experiment have not been analysed in such detail as those of the main experiment, but cols. 6–8, Table II, contain R as calculated from m, R as observed, and the ratio R/R_c; except for the gaboon, the ratios are equal to or slightly less than unity. The average ratio (omitting the gaboon) is 0·985 as compared with 1·005 in the main experiment. Evidently when estimating basic density R by the maximum moisture content method, the time required for maximum uptake must be carefully determined. With many of the timbers, a few hours or days is sufficient; with others, particularly gaboon and to a less extent ekki, a period of some months must be allowed, at least with the present technique.

ACKNOWLEDGEMENT

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BRITISH ASSOCIATION, GLASGOW

27 August–3 September 1958

THE Forestry Sub-Section will meet under the Chairmanship of Professor H. M. Steven. His address will be entitled 'The native pinewoods of Scotland and their significance for current forestry practice'.

There will be a joint session with the Agriculture Section on the integration of Agriculture and Forestry in Land Use (papers by Sir J. Denby Roberts, M. A. Dickie, and J. A. B. Macdonald), and with the Botany Section on Scottish Soils. Other sessions will be devoted to the supply and utilization of fast-grown coniferous timbers (Andrew Watt, B. J. Rendle, Findlay Wilson, and E. G. Richards), and forest tree seed (G. D. Holmes, J. R. Thom, and J. D. Matthews).

Excursions will be made to a number of forests in south-west Scotland, including Lochard, Lennox, Cowal, Lee and Carnworth, and Corrour. A visit will also be made to the Ari Mill.

The officers of the Forestry Section for 1958 are: Chairman—Professor H. M. Steven, University of Aberdeen; Secretary—Mr. T. H. Owen, Forestry Department, University College, Bangor; Local Secretary—Mr. H. A. Maxwell, Conservancy Office (West), 20 Renfrew Street, Glasgow, C. 2.

THE DISTRIBUTION OF MYCELIA IN EUROPEAN LARCH BARK, IN RELATION TO THE DEVELOPMENT OF CANKER

By W. R. DAY

(*Department of Forestry, Oxford*)

SUMMARY

The paper presents fully evidence to support the following conclusions.

1. The living bark of European larch (*Larix decidua* Mill.) may be expected to be infected with a microflora which contains both fungi and bacteria and which may sometimes include *Dasyscypha willkommii* (Hart.) Rehm.

2. The necrotic areas which constitute cankers can be found to contain a similar flora including *Cytospora abietis* Sacc., *C. curreyi* Sacc., and *Coniothyrium fuckelii* Sacc. This flora may include *D. wilkommii* but it is not necessarily the most abundant nor is its presence necessary for the development of larch canker.

3. Inoculation experiments at Mynydd Ddu, where canker and die-back of branches is severe, with the above species of fungus, show that inoculations stimulate extensions of dead bark. Under different site conditions and in a canker-free plantation at Southmoor, similar inoculations only produced extensions greater than those observed in control treatments, where the trees inoculated had been partially girdled.

4. A mass of mycelium of the usual species inhabiting living larch bark may, under suitable conditions, have an influence which favours canker extension but some special stimulus, of which the condition of the tree may be an important factor, is needed to enable them to influence the living bark of the host adversely. Much more careful study is needed before conditions which accompany canker development are accurately known.

THIS paper is concerned with the microflora of the bark of European larch and especially as this develops in connexion with the formation of cankers. Much work has been carried out on the nature of the complex disease which has resulted in the failure of this species in various parts of western Europe (Boyce, 1948) and a great deal of attention has been given to the larch canker fungus,* *Dasyscypha* (*Trichoscyphella*) *willkommii* (Hart.) Rehm; but little attention has been paid to the nature of the actual microflora of larch bark, whether within the necrotic area, or outside it. It has been assumed that this fungus is always present near to the edge of the canker and so is able to influence the live bark outside its edges; or as, for example, Hiley (1919) suggested for initial stages of canker development that having colonized dead branches, or areas of dead cortex, it is able to affect living bark from these and so begin the development of a canker. The fungus has been consistently regarded as not actually coming into contact with living tissue, but as causing its death in advance of mycelial extension, or, if Langner's (1936)

* This includes the two types separated by Hahn and Ayres (1943) and Manners (1953) as distinct species. The writer is not yet convinced that this separation properly covers the variability of *Dasyscypha* as found in European larch. Robak (1951) recognized variation but considered that this occurred only within the limits of one species. It appears that more detailed and extensive work is needed. The mycelia used in inoculation were obtained from spores from apothecia.

view is accepted, as so influencing the tissue which adjoins the canker edge, that it becomes unduly susceptible to frost injury. Langner assumed that if tissue were composed of green, live cells that it would be free from mycelium; and it would appear that this has been a usual assumption. The general conception has been that a canker represents an infected necrotic area set within living and uninfected bark.

Langner's contribution to the discussion of larch canker was of particular interest in that he not only put forward an interesting theory of canker development, but also identified zones of tissue in relation to this. There was the G zone of healthy tissue, outside the canker; an A zone of slightly affected tissue as an outer edge of this bordering the infected area and E zone of a few millimetres width, which was to be seen during sufficiently warm periods in winter, or at the beginning of the growing season, which in European larch in the plain in western Europe may be during the end of winter. The E zone might be repeatedly developed and constituted tissue which had been affected by the enzymes of the larch canker fungus, but not killed. It was much more susceptible to injury by frost than fully healthy tissue and when killed owing to low temperature, constituted the T zone. All the zones from G to T were considered to be free from mycelium, with the exception, possibly, of the inner edge of the T zone. A P zone occurred inside the T zone and constituted the region most recently and fully infected by mycelium: inside the P zone was the also fully infected, centre of the canker (Kr).

Langner's conception of fungus colonization of larch tissues in and around a canker was simple. There was complete fungus infection from the centre of the canker to the outer edge of browned, dead bark; the T zone, as recently killed tissue, was only to be observed during the first part of the year; it was then mostly free from mycelium. As time passed, it naturally became occupied by mycelium and became the P zone and, with the progress of summer, a cork layer was formed to cut off the injured tissues. The mycelium in the newly dead tissues, at the outer edge of the canker, had no adverse influence on the outer and healthy tissue during the growing season; but this became susceptible to its enzymes during periods of sufficiently high temperature during winter and in this way a new E zone was constituted, susceptible easily to frost injury: thus the cycle of development was started again. The larch canker fungus had no parasitic action: it merely affected cells physiologically so that they became more highly susceptible to frost injury.

This interesting hypothesis was attractive through its simplicity and the fact that it united divergent views; though work carried out since by Hahn and Ayers (1943) and Manners (1953) seems clearly to have weighted heavily the view that *D. willkommii* is able to act in such a manner that it can, in its own right and without the aid of any other than an initially wounding factor, cause cankers to develop. It is to be noted, however, that whether one inclines to Langner's view, or to another which allows the direct influence of a fungus in the development of canker, the assumption is made that the larch canker fungus is the active mycelium. Inoculation experiments, in particular, have been made on this basis and have

been considered to provide evidence for it. Experience in trying to isolate mycelia from bark known to be infected, suggested that this might prove to be an unduly simplified view of the state of affairs in cankered larch trees and that an attempt to investigate more closely the ecology of the microflora of larch bark, both within and without cankers might be worth while.

There were other reasons for such an investigation. The writer, some time ago (1931), took the view that frost injury played an important part in the development of larch canker in particular and the failure of larch, often referred to as 'larch disease', in general. If this were true and if one could assume that the living bark of larch was uninfected, then the initial injuries which constituted the first stages in the development of canker, should also be found to be sterile, if one attempted isolations at a sufficiently early stage. Small initial trials with material collected in a number of places during March and early April showed that many of the inocula from such initial injuries were sterile and often in too high a proportion to suggest that the injury itself had been caused by an infection; the mycelia isolated also represented a number of species. It was also indicated that the conception of larch bark outside a cankered area, as necessarily uninfected, was too simple. The work described below was carried out in an attempt to obtain a truer idea of the actual state of affairs and of the place of *D. willkommii* among such microflora as might occur. This work has necessarily largely been concerned with cankers and the zones which are to be observed in passing from outside into a canker have been recognized as follows:

A zone — The live bark outside the canker.

B zone — The canker extension zone of pale yellowish sodden-looking tissue: this usually occurs irregularly round the edges of a canker and is to be seen principally between January and April, inclusive. It may be only a millimetre or so wide; or it may be several centimetres wide.

B1 zone — An inner part of the B zone which has a slightly brownish appearance; it is situated next to the dead canker tissue and is the first formed part of the extension zone: it is not usually found until late winter or early spring.

C zone — Of dead, pale brown bark along the outer edge of the canker: it consists of a previously formed and now dead extension zone.

D zone — The dark brown and often somewhat resinous, dead, central tissues of the necrotic area. This zone was not usually sampled in this work.

The A zone is the same as Langner's G zone; the B and B1 zones appear to be included in his E zone, affected by the enzyme action of the fungus though the B1 zone may possibly be equated with his T zone; the C zone is presumably the same as his P zone, the first of his zones to be fully occupied by mycelium; while the D zone is the same as his Kr zone constituting the central mass of the necrotic area.

It will be seen later that attempted isolations were usually made in threes; one inoculum being taken from the A zone and about ½ inch beyond the extreme limit of the B zone should such exist, or of the C zone should there be no extension zone; another inoculum was taken from the B zone, or if this did not exist, from the outer edge of the C zone; while the third inoculum was taken from within

the C zone. It will be seen that cankers were also sampled by taking narrow strips of bark cut across all the zones present at the time: the strips were cut into small blocks, each block being used as an inoculum. This enabled some idea to be obtained of the distribution of mycelia in the different tissues on either side of canker edges. The usual precautions were taken in surface sterilization of the stem, or branch, sampled and of instruments used. This sampling of tissues was done as near to the site of collection as possible, in order that there might be no loss of condition in the tissues concerned.

The initial development of cankers. The development of a canker starts with the death of a usually small area of bark which may, but need not, be situated round a dwarf shoot or a small side branch. Such a patch of dead bark may girdle a small branch, the distal end of which then dies: this is to be observed commonly in suitable situations in spring. The affected branches are easily to be recognized because the leaves on the dwarf shoots remain only partly developed and become discoloured. The initial areas of injury can at first only be seen by scraping away the outer cork layer when, because of their darker colour, they stand out obviously from the surrounding apparently uninjured tissue. This difficulty of recognition makes continuous observation of their development also difficult. Observations on the frequency of their occurrence have been made periodically and principally in Mynydd Ddu Forest on the eastern Welsh border (Table I). They were relatively frequent in January 1955; they had also been comparatively easy to find in March 1953 and April 1954; but in July 1954, in the same area of observation as for April, they were scarce; while in October none could be found. Experience in many scattered places, in which the dying back of larch branches was occurring at least moderately severely, has been that they are usually easy to find in March and April. These observations apply to England and Wales and in England particularly to the more southerly part.

If one accepted the hypothesis that the primary injuries in the development of larch canker are caused by a physical factor and mainly by frost, it seemed inevitable that infection would be found to have occurred to a relatively slight extent if examination was made sufficiently soon after the injury had taken place: alternatively, if the larch canker fungus was responsible for the initial death of the tissues, it would be found in or near them. It should be noted that these injuries, when examined sufficiently soon after occurrence, show characteristics equivalent to the B zone described above in connexion with canker development. It should be noted also that the above hypothesis, that living bark of larch would be found to be free from mycelia, was tacitly assumed.

In order to test this idea, isolations were attempted at different times of the year (Table I) both from the discoloured tissue of the injured patch and from the surrounding live bark. There were several interesting results of this: firstly, it was discovered that live and apparently healthy bark not infrequently contained mycelia, though only rarely was *Dasyscypha willkommii* one of these; secondly that, while the injured areas were mostly infected, *D. willkommii* occurred much less frequently than other mycelia; also sometimes bacteria only were found; thirdly, the proportion of sterile inocula taken from the injured patches was often

TABLE I. *Attempted isolations from initial stage in canker development and from the surrounding living bark*

Forest	Date	Live bark					Initial dead patches					
		Total number	Percentage				Total number	Percentage				
			Sterile	Dasyscypha	Other mycelia	Bacteria		Sterile	Dasyscypha	Other mycelia	Bacteria	
Halfway	Mar. 1950	32	97·0	..	3·0	..	16	94·0	..	6·0	..	Provenance plots
Mynydd Ddu	,, ,,	32	91·0	..	9·0	..	16	94·0	..	6·0	..	Provenance plots
,, ,,	,, 1953	32	75·0	..	25·0	..	16	37·5	..	62·5	..	Provenance plots
,, ,,	,, ,,	30	66·7	..	33·3	..	30	40·0	26·7	33·3	..	Provenance plots dormant margin
,, ,,	,, ,,	66	89·4	..	10·6	..	66	30·3	15·2	54·5	..	Provenance plots active margin
,, ,,	Apr. 1954	58	50·0	..	46·6	3·4	58	13·8	27·6	58·6	..	G.R. plots, &c.
,, ,,	July 1954	8	37·5	..	50·0	12·5	8	12·5	..	75·0	12·5	,,
,, ,,	Oct. 1954	None found						None found				,,
,, ,,	Jan. 1955	100	11·0	1·0	78·0	10·0	100	7·3	10·4	76·0	6·25	,,
Coed-y-Brenin	Apr. 1948	54	94·0	..	6·0	..	18	78·0	5·5	11·0	5·5	

much too high to be consistent with the hypothesis that they were caused by infection; fourthly, there was usually no obvious wound, or previously dead tissue, from which infection might have spread, and lastly that these initial injuries seemed to have a season of occurrence. They were, thus, most easily to be found, as recent occurrences, in January, March, and April; they were difficult to find in July and could not be found at all in October. The indications were, thus, that the time of injury lay between autumn and spring and if the higher occurrences of sterile inocula from initial injuries are taken as indicating relatively recent occurrence, the usual periods indicated for injury are the late winter or early

TABLE II. *Attempted isolations from live bark on healthy uncankered, and from cankered (zone A), branches. Coed-y-Brenin, 1951*

Type of branch	*Month*	*Area in Coed-y-Brenin*	*Attempted isolations*			
			Total number	*Percentage*		
				Sterile	*Fungi*	*Bacteria*
Apparently healthy, uncankered	April	Penrhos Hill	50	86	10	4
	,,	Bont Ddu	50	100	..	..
	July	Tyn-y-Mynydd	37	100	..	..
Cankered branches; Isolations from live bark (Zone A)	April	Penrhos Hill	54	63	37	..
	July	Mynydd Caen-y-Coed and Tyn-y-Mynydd	66	71	29	..

spring. It is to be noted that the high proportion of infections among the inocula from initial injuries for January 1955 corresponds with a similarly high proportion from the inocula taken from the surrounding live bark and the suggestion plainly is that the isolated organisms were *in situ* before injury took place. It is also of interest to note that in this case *D. willkommii* was isolated from one of the inocula taken from living bark.

The infectedness of living bark. One of the principal problems raised by these observations is, thus, the nature and degree of infectedness in living bark outside areas of initial injury, or as will be seen, outside necrotic areas caused by canker development. Some observations were made in 1951, in Coed-y-Brenin, Merionethshire, in which bark on branches of trees which showed no canker, or dying back, was compared with bark on branches which bore cankers; the inocula, in both cases, were taken from living bark (Table II). The results suggest that living bark on trees which suffer from no apparent disease may be much more free from infection than that from branches which actually bear cankers. Further experience, summarized in Table III and referring to larch in Mynydd Ddu Forest, on the borders of South Wales, shows that there may be very great variations in degree of infectedness in living bark on canker-bearing branches. Six sets of eighteen isolations were attempted and the figures show that success in obtaining an infecting organism varied between one-sixth and two-thirds.

A further illustration is provided by the data in Table IV. These refer to an area at Southmoor, near Oxford, which was planted with a strain of European

larch of Scottish origin and in which there was practically no canker or die-back. A number of small patches were killed by local freezing in March 1955 and subsequently inocula were taken from the injured patches and also from uninjured bark outside them. The inocula for any one date were necessarily taken from a number of trees and the results may be taken as indicating the

TABLE III. *Examples of variation in proportion of inocula from living bark outside cankers (A zone) producing mycelia from European larch provenance plots, Mynydd Ddu Forest*

Number		*Per cent. infected*
Sterile	*Infected*	
15	3	16·7
14	4	22·3
14	4	22·3
13	5	27·8
8	10	55·7
6	12	66·7

TABLE IV. *Results of sampling for infection within and outside injuries caused by freezing on European larch at Southmoor, Berkshire*

Time of sampling from date of Treatment	1 day	*Weeks*									
		1	2	3	5	6	8	10	12	14	17
Within area of injury, number of samples. .	26	16	16	16	15	16	16	13	16	21	16
Per cent. with:											
Bacteria . . .	..	..	..	..	6·7	..	..	20·0	..	38·1	37·5
Mycelium* . . .	26·9	18·8	18·8	25·0	20·0	37·5	31·2	46·7	31·2	38·1	56·25
Sterile	73·1	81·2	81·2	75·0	73·3	62·5	68·8	33·3	68·8	23·8	6·25
½ inch outside area of injury, number of samples. .	27	17	16	16	14	16	16	14	19	17	12
Per cent. with:											
Bacteria . . .	3·7	5·9	..	..	..	..	..	..	15·8	5·9	16·7
Mycelium* . . .	29·6	23·5	18·8	25·0	35·7	18·8	43·8	21·4	47·4	17·6	..
Sterile	66·7	70·05	81·2	75·0	64·3	81·2	56·2	78·6	36·8	76·5	83·3

* No *Dasyscyphae* were obtained.

relative infectedness of living bark in these larch at the time. It will be seen that the proportion of successes in obtaining mycelia, from the two classes of inocula, was not appreciably different until after 8 weeks had passed.

Eventually a very great difference developed, the injury producing much the greater proportion of infections; though, as will be seen, considerable variations in proportion of sterile inocula occurred. The data, however, show clearly that in this plantation, situated distantly from either of the other areas worked in and showing little or no disease, it is usual for apparently healthy and certainly mainly living, bark to contain mycelia and bacteria. No attempt was made to identify all the organisms isolated. No *Dasyscypha* was isolated at Southmoor; but it was

obtained as one of the more unusual mycelia in both the Welsh areas. Among the more prominent species were *Cytospora abietis* Sacc., *C. curreyi* Sacc., and *Coniothyrium fuckelii* Sacc. This work has suggested that the fungus flora of larch bark varies appreciably from site to site: thus *Cyt. curreyi* was more common in Coed-y-Brenin, among the isolates, than in either of the other areas; *Cyt. abietis* and *Con. fuckelii* were usually common and sometimes abundant in Mynydd Ddu Forest; while at Southmoor, near Oxford, while all the named mycelia were present, other and as yet unidentified species were more common. The fact that species associated with canker development occur without any bark necrosis

TABLE V. *Attempted isolations from small brown spots in cortex of live branches and from the surrounding live bark*

Forest	*Date*	*Total number*	*Percentages (live bark)*				*Total number*	*Percentages (brown spots)*			
			Sterile	*Dasy-scypha*	*Other mycelia*	*Bacteria*		*Sterile*	*Dasy-scypha*	*Other mycelia*	*Bacteria*
Coed-y-Brenin	Nov. 1948	54	94·5	..	5·5	..	18	77·6	5·6	11·1	5·6
Mynydd Ddu	Mar. 1950	32	90·5	..	9·5	..	16	93·6	..	6·3	..
Halfway .	,, ,,	32	97	..	3·0	..	16	93·6	..	6·3	..
Coed-y-Brenin	Apr. 1952	18	78	..	22	..	18	50	..	44·5	5·5
TOTALS .		136	91·5	..	8·5	..	68	78	1·5	17·5	3·0

developing, suggests that the mere presence of the various mycelia is not, in itself, a cause of canker, or dying back of branches. It has not been possible yet to make a detailed examination for these mycelia, but the obvious inference is that they live in small centres of dead tissue which occur quite usually in what is mainly living bark. The slighter degrees of injury by frost, or drought, may be responsible for some of these; but a very obvious origin would appear to be injuries in the tissues caused by the sucking of *Adelges* species. These insects have occurred very commonly in all three areas worked in and in some years have been present in great abundance. The tissues of living bark which has been exposed to infestation may be seen to be speckled in brown in a manner similar to the speckling caused in beech bark by *Cryptococcus fagi*. These brown specks are easily to be distinguished by size from the initial injuries already discussed. Table V summarizes the results of attempted isolations from these brown specks and from the surrounding uncoloured bark: it will be seen that on the average the specks showed the greater degree of infection; though there need be no great difference. *D. willkommii* was isolated occasionally; but other mycelia were usually present.

The place of Dasyscypha *species in larch canker tissue.* From what has been said it will be seen that when the bark of a larch branch becomes injured, from whatever cause, there is a chance and sometimes a very great chance, that the injured area will include mycelia already established in residence. Sometimes *Dasyscypha willkommii* will occur; but often other mycelia will be present. The first systematic observations at Oxford, as to the presence of *D. willkommii* in the various zones to be distinguished at the edge of cankers (Table VI) were made by Wright (1951). They were carried out at Buckland, near Oxford, in a plantation of European larch which were moderately severely affected by canker and dying back,

on their lower branches. The site is slightly concave, in flat country and has a sandy soil. *D. willkommii* was identified by comparison of mycelial growth with that produced from spores obtained from apothecia. It will be seen that Wright found that the living bark (A zone) and the active extension zone (B zone) were mainly sterile, though *D. willkommii* was found sometimes and sometimes other species of fungus were also present. The inner extension zone (B1) was also mainly sterile; though there was a marked rise in the proportion of *D. willkommii*

TABLE VI. *Attempted isolations from cankers on European larch, 1951, from Buckland, Berks. after M. G. Wright*

Bark zone	*Total number of attempted isolations*	*Percentages*		
		Sterile	*Dasyscypha*	*Other mycelia*
A . . .	80	82·0	3·0	15·0
B . . .	58	89·0	3·5	8·5
B1 . . .	33	70·0	30·0	..
C . . .	74	14·0	85·0	1·0
D . . .	38	..	84·0	16·0

A. Living bark outside canker. B, active extension zone. B1, inner, browner, part of B. C, outer part of previous extension. D, centre of canker. Zone B appeared about 17th January; zone B1 about 2nd March. Observations dated from 12th January to 2nd May.

TABLE VII. *Percentages of active cankers observed in two areas of Mynydd Ddu Forest, South Wales, April 1954–January 1955*

Area ref.		*Month of observation*			
		Jan.	*Apr.*	*July*	*Oct.*
G. R. Plot	Number of cankers	8*	26	34	50
	Percent. active	12·5	26·9	8·8	2·0
Middle Plot	Number of cankers	26	70	51	50
	Percent. active	7·7	65·8	5·9	10·0

* Number low because of extremely severe weather conditions.

infected inocula. It was, however, only in the C and D zones, within the dead bark, that a really high proporton of the inocula produced this fungus. This work was begun on 12th January; the first active extension zone (B) was noticed on 17th January; the first inner extension zone (B1) was observed on 2nd March; the change from the rather sodden looking extension zones to the dry, brown, and dead C zone of course came later still.

Wright's observations obviously suggested that canker extension began in late winter. Some observations have been made in Mynydd Ddu Forest with regard to this (Table VII). Cankers were examined for extension at three-monthly intervals, beginning in April 1954 and ending in January 1955. The January figures are unsatisfactory because severe conditions of ice and snow prevented the examination of an adequate number of cankers. The general inference is, however,

that there is a rise to a peak of activity during the late winter and early spring; a fall to a low level during summer follows and this is maintained, possibly, until the middle of the next winter. Admittedly much more observation is needed with, regard to this matter; for instance it is known that extension sometimes takes place at the end of the growing season at the time of early frosts and there seems to be no reason why, locally, it might not then be severe. Examination of cankers, has, however, usually shown that extension occurred at the beginning of the growing season and this is what the figures indicate.

In order to obtain further information as to the occurrence of *D. willkommii* in larch cankers, further isolations were attempted in Coed-y-Brenin in 1951 and 1952 and in Mynydd Ddu Forest in 1953. European larch had been planted extensively in both forests and much of it had suffered severely from canker and dying back of branches. Three areas were selected in Coed-y-Brenin: one was in a narrow ravine-like part of the valley of the Afon Wen, near Tyn-y-Mynydd; another was on a bench on the south side of Penrhos hill; the third was on Mynydd Caen-y-Coed in the valley of the Afon Mawddach. The larch had been severely damaged in all three areas. Soil conditions are relatively even in the Penrhos area; but very irregular in both the others. The distribution of disease was, however, largely independent of soil fertility except where this was markedly low and trees tended to fail because of poor soil conditions. Differences appeared between the three areas; but in general they gave similar results and only a general summary is given here (Table VIII).

This shows that *D. willkommii* occurred occasionally but sparsely in the live bark (A zone); that it was isolated much more frequently, but was still a subsidiary mycelium, in the B zone, and that it was more frequent still, though it still remained a subsidiary mycelium, in the C zone. The proportion of inocula which were sterile was greatest in the A zone and least in the C zone: this is to be expected and is shown also in Tables VI, IX, and X.

A similar result was obtained in Mynydd Forest (Table IX). *D. willkommii* was not isolated from the A zone, though the data in Table X, which relate to another part of this forest, show that it may occur occasionally. Also it was not obtained from the B zone in two out of the three areas sampled, though it was present to an appreciable amount, especially in the August inocula, in the first area. It was plainly more abundant in the C zone, but was usually subsidiary to other mycelia. The data in Table X from the same forest, but from experimental provenance plots, are given separately. It is very doubtful whether any of the differences between the different provenances are significant; but the data agree in general with those presented in previous tables. *Cyt. abietis* and *Con. Fuckelii* were the two principal mycelia isolated at *Mynydd Ddu*, apart from *D. willkommii*.

The data presented indicate that, though *D. willkommii* is usually to be isolated from some part of a larch canker, it need not occur in the extension zone, which may be sterile, or may contain other mycelia. It is more commonly to be isolated from the outer edge of the completely dead bark (C zone), though even here it may be absent and other mycelia may commonly be found. The cankers sampled in Coed-y-Brenin, in 1951 and 1952, are separated in Table XI, according to

TABLE VIII. *Attempted isolations from cankers on European larch, 1951 and 1952, Coed-y-Brenin, N. Wales*

	Zone A					*Zone B**					*Zone C*				
		Percentage					*Percentage*					*Percentage*			
Date	*Total number*	*Sterile*	*Dasy-scypha*	*Other mycelia*	*Bac-teria*	*Total number*	*Sterile*	*Dasy-scypha*	*Other mycelia*	*Bac-teria*	*Total number*	*Sterile*	*Dasy-scypha*	*Other mycelia*	*Bac-teria*
1951 April	54	63·0	1·8	35·2	..	108	52·8	7·4	38·9	0·9	54	27·8	27·8	44·4	..
July	66	64·3	1·6	27·8	6·3	131	21·7	12·7	63·8	1·6	65	6·6	14·5	75·5	3·3
1952 April	54	81·5	..	14·8	3·7	108	62·9	3·7	29·6	3·7	54	27·8	11·1	59·3	1·8
July	54	87·1	..	11·1	1·8	84	79·0	3·1	17·9	..	54	31·5	18·5	50	..
Apr. 1951 and 1952	108	72·2	0·95	25·0	1·85	216	57·8	5·6	34·2	2·3	108	27·8	19·4	51·8	0·9
July 1951 and 1952	120	75·7	0·8	19·4	4·0	215	50·4	7·9	40·8	0·8	119	19·1	16·5	62·8	1·6
1951	120	63·5	1·7	31·5	3·3	239	37·3	10·5	51·3	1·2	119	17·2	21·2	60·0	1·6
1952	108	84·3	..	12·9	2·8	192	71·1	3·4	23·7	1·8	108	29·6	14·8	54·7	0·9

* Sampled in cankers without and in cankers with apothecia of *D. willkommii*: there was no significant difference in the result.

TABLE IX. *Attempted isolations from European larch cankers in three areas in Mynydd Ddu Forest*

Area	Month of sampling	Zone A (live)					Zone B (recent extension)					Zone C (previous extension)				
		Total number	Percentage				Total number	Percentage				Total number	Percentage			
			Sterile	Dasyscypha	Other mycelia	Bacteria		Sterile	Dasyscypha	Other mycelia	Bacteria		Sterile	Dasyscypha	Other mycelia	Bacteria
1st Area . .	March	36	77·8	..	22·2	..	36	16·6	19·4	64·0	..	36	8·3	22·2	69·5	..
	August	35	57·2	..	40·0	2·8	3*	..	33·3	66·7	..	36	11·1	36·1	52·8	..
2nd Area . .	March	36	39·0	..	55·5	5·5	36	19·4	..	77·8	2·8	36	2·8	5·5	91·7	..
	August	No isolations attempted														
3rd Area . .	March	36	77·8	..	19·4	2·8	36	36·1	..	61·1	2·8	36	13·9	8·3	77·8	..
	August	35	71·4	..	25·7	2·8	3*	33·3	..	66·7	..	36	13·9	50·0	36·1	..
Totals . .	March	108	64·8	..	32·4	2·8	108	24·1	6·5	67·5	1·9	108	8·5	12·0	79·5	..
	August	70	64·3	..	32·8	2·9	6*	16·7	..	83·3	..	72	12·5	43·0	44·5	..

* Number low because of low occurrence of recent extensions.

TABLE X. *Attempted isolations from European larch cankers, August 1953, from the provenance plots, Mynydd Ddu Forest*

	Zone A					*Zone B*					*Zone C*				
		Percentage					*Percentage*					*Percentage*			
Provenance	*Total number*	*Sterile*	*Dasy-scypha*	*Other mycelia*	*Bac-teria*	*Total number*	*Sterile*	*Dasy-scypha*	*Other mycelia*	*Bac-teria*	*Total number*	*Sterile*	*Dasy-scypha*	*Other mycelia*	*Bac-teria*
Bohemia	36	69·5	..	30·5	..	6†	16·7	..	83·3	..	36	2·8	50·0	47·2	..
Austrian Alps	36	80·6	..	19·4	..	6†	66·7	..	33·3	..	36	2·8	30·5	66·7	..
Italian Alps	36	47·2	8·3	41·7	2·8	6†	50·0	..	50·0	..	36	5·6	61·1	33·3	..
Darnaway Scotland	30*	73·4	3·3	20·0	3·3	9	44·5	33·3	22·2	..	30*	26·7	26·7	46·6	..
Totals	138	67·4	2·9	28·3	1·4	27	44·4	11·1	44·4	..	138	8·7	42·8	48·5	..

* Low because of sparsity of cankers on this provenance.
† Low because of difficulty of finding recent extensions.

whether *D. willkommii* was present, or absent, among the mycelia obtained from the inocula. The results show that it was absent in the majority of cases. This does not prove that it was absent from the cankers sampled; but merely that it did not grow out of the inocula taken in sampling. On the basis of this sampling there is, however, a very significant suggestion that *D. willkommii* is not necessary for the development of canker in European larch.

Strip isolations across the edges of cankers. These were made in order to obtain some idea of the manner of variation in mycelial occupation of larch bark on either side of the edges of cankers. The results are shown in Figs. 1, 2, and 3.

TABLE XI. *Proportions of European larch canker from which* Dasyscypha *was isolated—Coed-y-Brenin, N. Wales*

Year	*Month of sampling*	*Total* Number sampled*	*Number in which the inocula were*			*Percent. with Dasyscypha*
			Sterile	*With Dasyscypha*	*Without Dasyscypha*	
1951	April	36	5	10	21	27·8
	July	44	1	14	29	31·8
1952	April	38	2	8	28	21·0
	July	36	1	4	31	11·1

* From three separate areas, roughly equally.

The bark surface was first sterilized with mercuric chloride and the outer surface removed with a sterile scalpel: a second and very thin slither of bark was then removed in the same manner to ensure as clean a surface as possible. A narrow strip of bark was then cut out, which extended across the canker edge, from the apparently healthy tissue of the A zone to the dead tissue of the C zone. The strip was divided into small blocks of about equal size. Each of the blocks was then placed on culture medium, except in the case of the first trial (Fig. 1), in which sample blocks were taken at the intervals indicated. The first sampling after this manner was carried out in March 1953, and the second in January 1955; both being done in Mynydd Ddu Forest. The third sampling was carried out near Tyn-y-Mynydd, Coed-y-Brenin, in August 1955. It will be seen that in the January and March samplings an extension or B zone was usually present; but that in August 1955, only one out of fifteen strips showed a B zone.

These trials show quite clearly, firstly, that the living bark outside the canker is generally, though often sparsely, infected and that the infecting mycelia include species which occur also within the necrotic area: *Dasyscypha willkommii*, as well as the other species named here, were among these. Secondly, that *D. willkommii* may be entirely absent from a strip, as tested in the manner indicated, or if present it is usually mixed with other fungi. Also, as the results set out in Fig. 2 show, there may be a very high degree of infection on either side of the canker edge, one species of fungus, in this case *Cyt. abietis*, being predominantly present. The results also suggest that, while the infecting mycelia are probably confined

mainly to a relatively small number of species, those which predominate at one site may be different from those which predominate at other sites.

The presence of bacteria is noted in Figs. 2 and 3. It will be seen that these may occur in all the zones recognized. Their presence is an indication that the

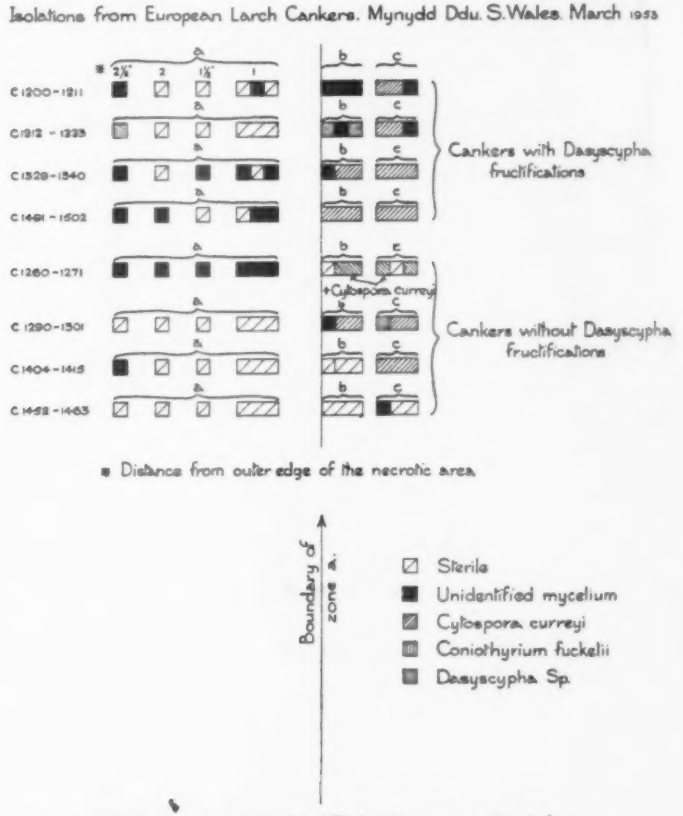

FIG. 1. *a*. Healthy tissue. *b*. Freshly killed active zone. *c*. Dead tissue.

sampling was carried out in bark subject to a general infection: indeed the generally mixed distribution of mycelia also is evidence for this. There is thus no evidence that there is any special association between canker formation and the mycelium of *D. willkommii*, or that of any other particular fungus. Plainly these results do not dismiss the problem of the influence of mycelia on canker development; though the occurrence of the principal species outside cankers as well as within them, suggests that any effect they may have must be of a secondary nature. There remains, however, the possibility that, when aided by some other injurious factor, they may cause some extra dying back of bark to take place and

so aid canker extension. This is essentially the role which Langner (1936) claimed for *D. willkommii* and for which the various inoculation experiments carried out since the time of R. Hartig, provide supporting evidence (Hahn and Ayres, 1943; Hartig, 1880; Hiley, 1919; Manners, 1953; Plassmann, 1927).

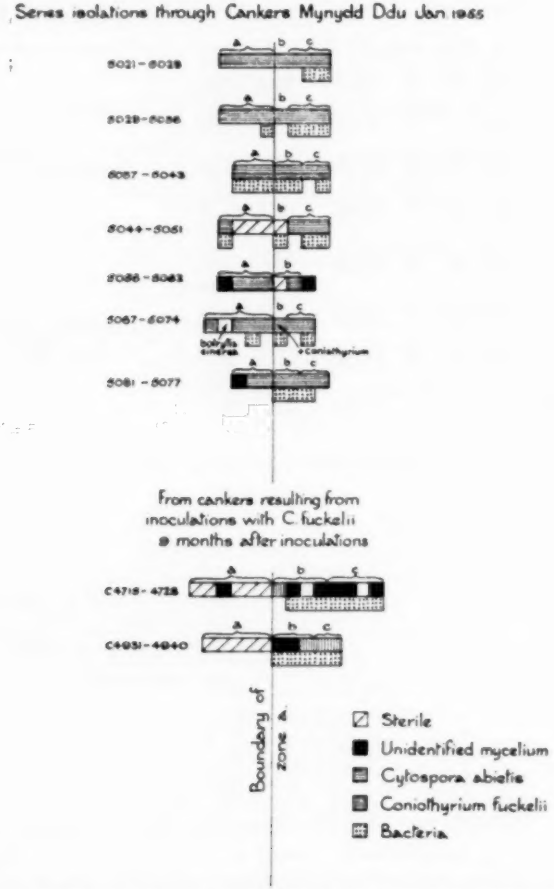

FIG. 2. *a*. Healthy tissue. *b*. Freshly killed active zone. *c*. Dead tissue.

Inoculation experiments with mycelia isolated. The inoculation experiments now discussed were made to test the hypothesis that some at least of the mycelia isolated might have some influence on the extension of cankers. The work was carried out in Mynydd Ddu Forest and also in the plantation at Southmoor, near Oxford. Mynydd Ddu represents an area in which disease has been prevalent and Southmoor one in which, so far, it has been negligible. The evidence already

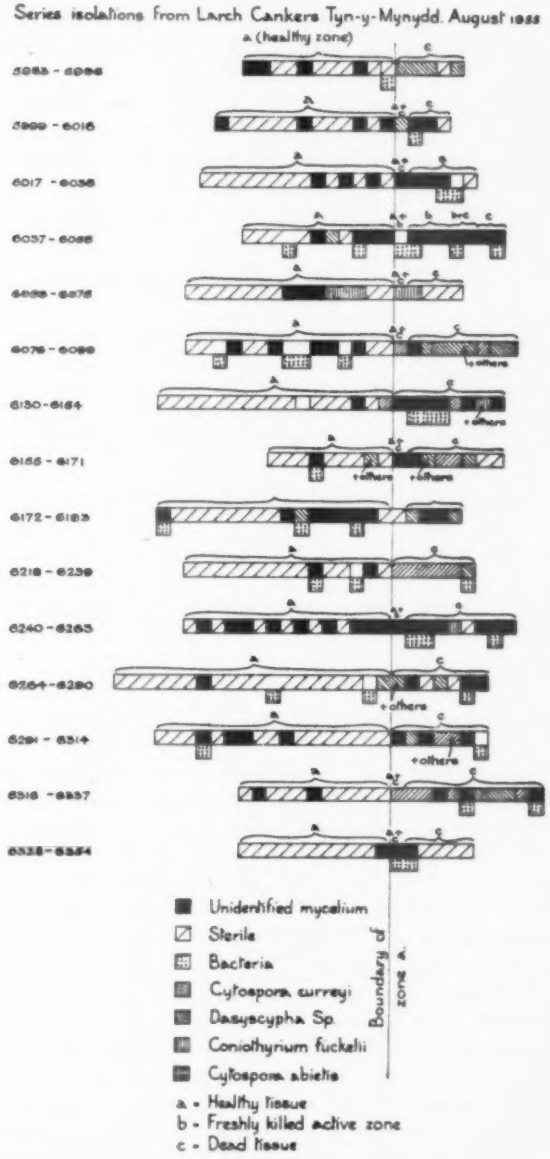
Series isolations from Larch Cankers Tyn-y-Mynydd. August 1933
a (healthy zone)
5985 - 6004
5999 - 6016
6017 - 6036
6037 - 6056
6057 - 6076
6076 - 6096
6130 - 6164
6166 - 6171
6172 - 6193
6218 - 6239
6240 - 6263
6264 - 6290
6291 - 6314
6316 - 6337
6338 - 6354
+others
Unidentified mycelium
Sterile
Bacteria
Cytospora curreyi
Dasyscypha Sp.
Coniothyrium fuckelii
Cytospora abietis
Boundary of zone a
a - Healthy tissue
b - Freshly killed active zone
c - Dead tissue

FIG. 3

TABLE XII. *Results of inoculations made in Mynydd Ddu Forest, 1954–5*

Month of inoculation	*July*					*October*					*January*					*April*				
Mycelia Inoculated	*Cytospora curreyi*	*Dasyscypha* (3 strains)	*Cytospora abietis*	*Coniothyrium fuckelii*	*Controls*	*Cytospora curreyi*	*Dasyscypha* (3 strains)	*Cytospora abietis*	*Coniothyrium fuckelii*	*Controls*	*Cytospora curreyi*	*Dasyscypha* (3 strains)	*Cytospora abietis*	*Coniothyrium fuckelii*	*Controls*	*Cytospora curreyi*	*Dasyscypha* (3 strains)	*Cytospora abietis*	*Coniothyrium fuckelii*	*Controls*
(1) Number of Inoculations . . .	13	38	13	13	27	18	53	18	18	32	16	46	15	16	34	18	54	18	18	36
(2) Per cent. of (1) showing significant extension	84·5	50·0	46·2	92·4	15·5	55·5	49·1	22·2	88·9	11·1	87·5	80·4	46·7	48·3	23·5	72·2	79·5	61·0	88·9	33·3
(3) Per cent. of (1) from which the inoculum was re-isolated . . .	Nil	10·05	15·4	77·0	..	5·6	Nil	11·1	44·4	..	Nil	10·9	26·6	25·0	..	16·7	9·3	27·8	72·3	..
(4) Mean extension weight . . .	1·44	1·51	1·61	2·59	0·75	1·50	1·73	1·30	1·8	0·42	1·66	1·83	2·44	2·08	1·75	1·27	1·09	1·31	2·41	1·15

Extension weights: 1 = $\frac{1}{16}$–$\frac{1}{4}$ in.; 2 = $\frac{1}{4}$–$\frac{1}{2}$ in.; 3 = $\frac{1}{2}$–$\frac{3}{4}$ in.
Significant extension = >$\frac{1}{4}$ in., or >1·0.

presented shows that any inoculation must necessarily be made into bark which is more or less infected and that it is possible and in some cases highly probable, that the fungus used as inoculum may already be present in the tissues treated. There can, therefore, be no question of maintaining a pure culture of the inoculum within the infected bark: it is merely possible with some certainty to introduce a special mass of the organism used as inoculum, under circumstances in which it may have favourable conditions for development, assuming susceptibility of the tree under the circumstances of inoculation. The inoculum used in this work always consisted of mycelium raised on malt-extract agar. It was usually inserted

TABLE XIII. *Attempted re-isolations of inocula from European larch in Mynydd Ddu Forest*

Inoculated mycelium	*Total number of attempted re-isolations*	*Percentage of successful attempts to re-isolate inocula in*				
		Total number	*July*	*Oct.*	*Jan.*	*Apr.*
Cytospora curreyi . . .	118	11·8	36·7	Nil	3·1	7·7
D. willkommii (A) . . .	116	10·3	11·5	10·0	6·7	13·3
„ (B) . . .	116	8·6	Nil	14·3	Nil	23·1
„ (C) . . .	116	11·2	25·0	7·15	6·7	6·7
Cytospora abietis . . .	102	36·2	42·3	30·7	23·5	62·5
Coniothyrium fuckelii . .	128	53·7	50·0	65·4	47·2	56·7

The quarterly re-isolations occurred in approximately equal numbers.

into wounds made with a scalpel, taking the usual precautions with regard to surface sterilization; but sometimes injuries were made by local freezing and the inoculum placed on the surface of the bark so killed. The measurement of extension was done only in the case of inoculation into scalpel wounds; this was because of the greater ease of accurate measurement of extension with such wounds than in the case of injuries made by freezing. The results of inoculation were classified according to the degree of extension of dead bark from the wound edges.

These results, for Mynydd Ddu, are summarized in Tables XII–XIV. Table XII gives the percentage of inoculations which showed significant extension, the percentage from which the inoculum was re-isolated, and the mean extension weight. It will be seen, firstly, that the inoculated wounds showed a greater proportion of significant extensions than did the controls. *Cyt. abietis* proved to be the least and *Con. fuckelii* the most effective inoculum. Secondly, that, except in the case of *Con. fuckelii* in April and July, the inoculum was re-isolated only in a low proportion of cases and sometimes not at all. *Cyt. curreyi* and the *Dasyscyphae* were the least satisfactory in this respect. Thirdly, as judged by mean extension weight and in comparison with the controls, the July and October inoculations showed the most significant extensions; while in April only the *Con. fuckelii* inoculations gave a significant mean extension beyond that for the controls. Further, this fungus gave the highest mean extension weights,

except in January, when it was second to *Cyt. abietis*. Taking the results as a whole the suggestion plainly is that *Con. fuckelii* had the greatest influence of any of the inocula in stimulating the dying back of bark round the wound edges. The low proportions in which the other inocula were re-isolated makes it difficult to assert with any certainty that the observed extensions were directly due to their action. It should be noted that often other mycelia or bacteria were also isolated in cases of successful re-isolation of the mycelium inoculated and that from nearly all inoculations an organism of some kind was obtained.

TABLE XIV. *Results of inoculations for all types of mycelia, summarized for time of inoculation and time of isolation. Mynydd Ddu Forest*

	Month of inoculation				*Total*		*Controls*	
	July	*Oct.*	*Jan.*	*Apr.*	*Number*	*As percent. of total inoculations*	*Total number*	*Percent. showing significant extension*
Period in months of delay in re-isolation — 3 — Per cent. showing significant extension	62·5	64·0	55·6	66·7	82	62·2	44	20·4
3 — Per cent. successful re-isolation	20·8	13·9	11·1	36·2	27	20·2	..	..
6 — As above	63·4	44·4	74·3	72·3	84	63·2	44	15·9
6 — " "	20·0	8·4	19·3	19·4	22	16·5	..	..
9 — " "	60·9	48·6	84·6	91·7	86	71·6	41	26·8
9 — " "	21·7	8·6	11·5	16·6	17	14·2	..	..
(A) Total number of inoculations showing significant extension	48	56	65	83	252	..	..	..
(A) As percentage of total inoculations	62·4	52·4	70·0	76·8	66	..	..	..
(B) Total number showing significant extension and from which inoculum was re-isolated	16	11	13	26	66	..	..	..
(B) As percentage of total inoculations	20·4	10·3	14·0	24·4	17·2	..	..	..

Total number of inoculations was 385.

Table XIII shows the proportion of cases in attempted re-isolation, in which the original inocula were re-isolated, according to month of attempted re-isolation and species of mycelium used. It is shown that *Con. fuckelii* was obtained from just over half the inocula taken from wounds into which it had been inserted; *Cyt. abietis* from more than a third; and the others from about a tenth or less, taking all times of re-isolation together. The season of attempted re-isolation seemed to be important in some cases: thus *Cyt. curreyi* was most successfully re-isolated in July and one strain of *D. willkommii* in April, but another in July. The least variation in the proportion of successful re-isolations occurred in the two species most successfully obtained, namely *Con. fuckellii* and *Cyt. abietis*. It will be seen that on three occasions there was no successful re-isolation, though actually some significant extension had occurred.

The results of all the inoculations are summed up in Table XIV, those from the different inocula being added together so that a mean result is obtained. It will be seen that the highest proportion of significant extensions was obtained from inoculation in April, the next highest in January and the least in July. Re-isolation of inoculum was successful in the order April, July, January, and October, the latter being the least successful. The effect of delay in attempted

re-isolation was to decrease the proportion of successes from 20·2 per cent. after 3 months, to 16·5 per cent. after 6 months, and to 14·2 per cent. after 9 months. The effect of delay in examination, on the proportion of inoculations to show significant extension was slightly to increase it.

It will be seen that if the data are examined in terms of either month of inoculation, or time of re-isolation, various trends appear which may, or may not be significant, but which probably would pay for closer examination. Thus the increase in proportion of inoculations which showed successful extension, with delay in examination, is determined by the marked increases associated with the January and April inoculations. The proportions for July remained relatively constant; while those for October actually fell. These results plainly show that unaccounted effects have entered in and they indicate the need for closer investigation. The April and then the July inoculations were followed by the greater proportions of successful re-isolations, both the October and January inoculations were much poorer in this respect. Thus the April inoculations proved the most successful both from the point of view of extension and re-isolation. Comparison with the controls shows that inoculation had a very marked effect in raising the proportion of significant extensions and taking the data as a whole, one is compelled to the conclusion that the introduction of mycelium in some way significantly influenced the extent to which bark died round the wound edges.

A more limited series of inoculations was carried out in March 1955, at Southmoor, near Oxford, in a plantation of European larch of Scottish origin from Aldraughty, Nairnshire, which has hitherto remained practically free from canker or dying back of branches, and the situation of which is entirely different from that of the larch in Mynydd Ddu Forest. Some of the trees inoculated were partly girdled. This was done in three ways; first the main stem was half girdled in two places, on opposite sides, but at different levels; second, stems were half girdled on one side only; third, stems were three-quarters girdled. There were no significantly different results from the different treatments and in the summary of results (Table XV) the different types of girdling are lumped together. The inoculations were made above the point of girdling. The results show that on the average, there was no significant difference in extension according to the position on the girdled trees of the inoculations; but it is plain that, as at Mynydd Ddu, the inoculated wounds showed a greater extension than the uninoculated. It is also interesting to note that inoculations made on non-girdled trees resulted in a lower mean extension weight than was obtained for inoculations on girdled trees; this is particularly obvious for one of the *Dasyscyphae* and for *Cyt. abietis*. There is certainly a suggestion here that partial girdling may have had some influence in raising the susceptibility of the tissue round the wound edges, to the influence of the inserted mycelium. The mean extension weight for the controls for the non-girdled trees is obviously not significantly different from that for the inoculations, nor from the controls for the girdled trees and it must be concluded that, on the non-girdled trees, inoculation had no significant effect. Of the mycelia tried, *Cyt. curreyi* had the least effect and then the *D. willkommii* derived from an apothecium from an extending canker. The highest mean extension weight

was obtained by *Cyt. abietis* and next by the *D. willkommii* derived from an apothecium from a dead branch. Comparison with Table XII, for Mynydd Ddu, shows that the higher mean extension weights were appreciably lower than those obtained there but that, in general, the extension weights covered much the same field.

Conclusion and summary. 1. The work presented, carried out in three widely separated areas in England and Wales, shows that the living bark of European larch, on branches or stems of a size on which canker usually is found to develop and in plantations subject, more or less, to the usual stresses from frost, drought,

TABLE XV. *Inoculations of European larch made at Southmoor, near Oxford on partly girdled and non-girdled trees*

Inoculum	Inoculation of partly girdled trees				Inoculation of non-girdled trees	
	Above the side treated		On the side not treated			
	Number of inoculations	Mean extension weight	Number of inoculations	Mean extension weight	Number of inoculations	Mean extension weight
Cyt. curreyi	6	1·17	4	1·25	4	1·25
D. willkommii (from canker)	6	1·3	4	1·25	4	1·5
D. willkommii (from dead stem)	6	1·6	4	1·75	4	1·0
Cyt. abietis	6	1·3	4	2·0	4	0·75
Con. fuckelii	6	1·6	4	1·25	4	1·25
Mean for all inoculations		1·63		1·87		1·15
Controls	12	0·91	8	1·25	8	1·0

Extension weights: 1 = $\frac{1}{16}-\frac{1}{8}$ in.; 2 = $\frac{1}{8}-\frac{1}{4}$ in.; 3 = $\frac{1}{4}-\frac{3}{4}$ in.
Significant extension counted as $>\frac{1}{8}$ in., or $>1{\cdot}0$.

and insect infestation, may be expected to be infected with a microflora which contains both fungi and bacteria and which sometimes includes *Dasyschypha willkommii*, the larch canker fungus. The foci of infection for this microflora have not been determined, but they are presumably to be found in the small groups of dead and often collapsed cells which occur commonly in the living bark of larch branches.

2. The necrotic areas which constitute cankers can be found at all stages of development to contain a similar flora: species identified both in the living bark and in the dead bark of the canker area are, *D. willkommii*, *Cyt. abietis*, *Cyt. curreyi*, and *Con. fuckelii*. Many other species of fungus occur, apart from bacteria, but those named have usually been found to be the more abundant. It is shown that *D. willkommii* is not necessarily the most abundant mycelium in larch cankers, even in the tissue near to the canker edges and the data presented give strong evidence that its occurrence is not necessary for the development of larch canker. On the other hand, the evidence shows that, even if the initial injury in canker development is physical in nature, mycelia may be expected to be present in or near the affected area and as influenced by the provision of a more abundant food supply, may play some part in stimulating canker extension. No

study has been made in this case of the bark surface microflora on European larch, but preliminary studies of this nature on *Fagus silvatica*, the common beech, suggest that most at least of the mycelia found in larch bark would also be represented among this microflora.

3. Inoculation experiments have been carried out in Mynydd Ddu Forest with the species of fungus named above, and these have shown that the insertion of inoculum into a wound stimulates a greater extension of dead bark around this, than if the wound is left uninoculated. European larch in Mynydd Ddu Forest have been subject severely to canker and dying back of branches, mainly on provenances of Alpine origin, and as a comparison to the inoculations made there a second, though smaller set, was made on European larch of Scottish origin, in a plantation near Oxford, which was practically free from canker and dying back. Inoculations here showed no significant difference in extension from uninoculated controls except in cases in which partial girdling had been carried out on the trees treated. The same species of fungi were used as at Mynydd Ddu. Differences in local climate, as well as in strain of tree may have had influence here. These are matters which remain to be determined.

4. It must be concluded from this work that a mass of mycelium, at least of any of the species here tried, may under suitable conditions for development, have an influence which favours canker extension. It needs particularly to be noted that the mycelia referred to are usual habitants of foci in living larch bark in which no canker is developing and the conclusion is inevitable that some special stimulus is needed to enable them to influence the living bark of the host adversely. It is not proposed to discuss here what this might be, but plainly the provision of a relatively abundant food supply is likely to be of great importance. The relative failure at Southmoor for inoculation to make any significant difference to extension of dead bark, except on partly girdled trees, suggests that the condition of the tree may be a factor of great importance in determining susceptibility to the influence of the inoculated mycelia. The anatomical evidence from cankers is that the death of tissue commonly takes place in the spring, round about the time of renewal of meristematic activity, though it is known from field examination that canker extension may take place at other times of year also. Much more careful study of case histories in relation to local environmental conditions, than has yet taken place, is needed if the conditions which accompany canker development are accurately to become known.

ACKNOWLEDGEMENT

It is desired to acknowledge, with many thanks, the help and interest in the work of Mr. D. K. Barrett, who was responsible for carrying out the field work and for supervising the maintenance and care of the cultures.

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FUTURE MEETINGS OF THE SOCIETY

THIS year, 1958, by courtesy of the Dartington Trustees, the Society hopes to meet in Devon with headquarters at Dartington from 22nd to 26th September and to visit Park Wood, King's Wood, Buckfastleigh and Clifford Woods on the Dartington estate and the state forests of Fernworthy and Haldon. An account of the forests of south-west England by G. D. Rouse and H. L. Edlin will be found in this number starting at page 27.

In 1959 the north of Scotland is to be visited from 21st to 25th September with headquarters probably at Inverness.

In 1960 it is hoped to visit the Ardennes in September and if so to hold the annual general meeting together with an excursion in Great Britain in May as was done in 1955 when the Society went to Denmark.

'It is also hoped to be able to arrange a further meeting annually in future mainly for the purpose of discussion. If this can be arranged, it is thought that the meeting should be of two days duration and be held in a university town at a time when inexpensive hostel accommodation is available. Details have still to be worked out before this proposal can be put in concrete form.

HONOUR

In Her Majesty's New Year Honours, 1958. Mr. Johnston Edwards to be M.B.E.

THE SOCIETY IN EAST ANGLIA, 1957

I. THE SOCIETY'S MEDAL: MR. W. E. HILEY

WHEN the Society met in Norwich for the 30th Annual General Meeting on the 25th September, it decided unanimously to award its Medal to Mr. W. E. Hiley and the medal was presented to him by the President amid applause.

A photograph of the Society's Medal will be found in *Forestry* xx at page 80. Mr. Hiley is the fifth recipient of the medal, the other four being Lord Robinson in 1947, Mr. Ray Bourne posthumously in 1949, Sir John Stirling-Maxwell in 1950, and Professor Steven in 1954.

II. THE EXCURSION

24th and 26th September. Thetford Chase. On the 24th, Elveden Beat was visited and some early experiments with the introduction of beech (*Fagus sylvatica*) into pine plantations were examined. Dr. Rishbeth of Cambridge University joined the party for a discussion on *Fomes annosus*. Thinnings, including the limitations and uses of early mechanical thinnings, were considered. The village and district office at Santon Downham were seen and the creosoting plant and Thinnings house were inspected. On the 26th, Roudham Beat was visited and the raising of oak (*Quercus*) with Scots pine (*Pinus sylvestris*) nurses was discussed. Brandon Depot, which deals with the conversion of all thinnings from Thetford Chase, was visited. For further details, reference is invited to Mr. Backhouse's article, 'Thetford Chase, Swaffham, and King's Forests', to Dr. Rishbeth's, 'Some Further Observations on *Fomes annosus* Fr.' both to be found in *Forestry*, xxx, no. 1, and lastly to the very excellent handbook prepared for the excursion by the Forestry Commission and supplied to each excursionist, which gives in addition to several useful tables and a map, details of the management at Brandon Depot, and the reasons why concentration of conversion at a central depot is favoured against conversion in the wood or at road-side. This handbook also contains a table showing the sizes, types, and prices of produce prepared at Brandon together with the piece-work rates paid in 1957 for cross-cutting and stacking, peeling (Kingsland), and for loading. The Society thanks Mr. Backhouse and his staff and Dr. Rishbeth for their valuable demonstrations in the woods and at the depot.

25th September. Ryston and Weasenham Estates. The great privilege of visiting these two very famous estates was much appreciated as was the very great care and trouble taken by the owners, Colonel Pratt and Major Coke, to make the visit so interesting and instructive. To both owners, the Society owes a considerable debt of gratitude. Most of us would have liked to have been able to stay far longer at both places and it is only possible in this account to select a few points of importance and reference is again invited to the Forestry Commission handbook of the excursion.

At Ryston, it was interesting to have confirmation that young poplar stock should be disturbed as little as possible in the nursery, i.e. not cut back or transplanted. That stock planted out at one or two years gives better results than older stock. That some of the finest results are got when poplar is planted out to fill gaps in woods. That if unrooted sets are to succeed if planted out in hedgerows, woodland, or in coarse grass, great care must be taken to reduce competition from the surrounding growth and roots. At Ryston the canker-resistant form of *Populus eugenii* is considered the most promising of all with *P. robusta* a good second.

Mr. Morley Penistan has kindly supplied the following brief note about Weasenham.

'The New Plantation at Weasenham afforded a wonderful opportunity to study one of the least regular woodlands in Britain. Despite exposure and the reputation of the soil, very satisfactory forest conditions have been built up over the last seventy years. There are small stands with fine stems, particularly of Douglas fir (*Pseudotsuga taxifolia*), which show the excellent form associated with growth in side shade; straightness, fine branches, some natural pruning and, as a result of selective improvement fellings, long crowns. These are admirable. Others, where larch (*Larix*), albeit too limited in crown development to make fine timber trees, has been under-planted, had excellent *Thuya plicata* and *Chamaecyparis lawsoniana* saplings below and among Douglas fir poles. Elsewhere the good form of widely spaced specimen trees in side shade shows the advantages of planting in forest conditions. It is not a perfect example of irregularity; the oldest Scots pine is very rough, and now it is overtopped by younger firs it would seem reasonable to remove it and some of the rough early free grown Douglas; the middle-aged larch and pine has become short crowned and unable to respond to new growing space, while the larch planting in clearings is far too dense and will retard the advantageous ad-mixture of natural seedlings of tolerant trees. The lack of figures of size class distribution and growing stock is regrettable in this most valuable woodland. Quick counts showed the stocking to be far from normal—66 square feet hoppus per acre basal area, with a volume of some 1,600 cubic feet hoppus per acre. In spite of the dismal weather, however, to visit and admire this monument to the great skill of Major Coke's father and to his continuing management, was a memorable experience.'

III. DISCUSSION

The debate was arranged to enable both the marketing of small thinnings and the Watson Report on Marketing of Woodland Produce to be discussed.

Mr. Penistan opened on a deliberately controversial note. He considered the case for working up markets to take small early thinnings was not a very good one. A great deal of labour was needed to prepare a very low-quality product, with a high proportion of bark on bad propertied juvenile timber. At Brandon, for instance, a large percentage of the produce sold at a price which could leave little margin for profit. As it was unreasonable to strive after high prices for low-quality timber, it would often be better to leave it in the wood. It had little effect on the growth of the best stems, and wherever possible should be allowed to grow on by making crown thinnings, provided that it did not affect the wood's final health adversely. This was appreciated in many parts of the world where plantation conifers were managed, for example in Queensland where the worst poles were cut and left lying at 3 years to allow the crop to pass quickly into utilizable size and spacing widened as soon as elite stock was available. If, however, such produce must be marketed the solution was to offer large amounts to attract special industries.

Mr. Rouse hardly accepted the above view but confined his attention mainly to two points relating to small estates. Firstly, markets for their small produce had not increased and such markets as there were required expert salesmen to open them up. Small estates should join together and share a first-class man. The first thing that this salesman would want to know would be what kinds and amounts of small produce were likely to become available and he would want this information well ahead. The estates participating would therefore require thinning plans, felling plans, and planting plans, in other words, proper plans of management. Sales could then be arranged well ahead. Secondly, it was no good holding out for higher prices than this small inferior timber was worth. Given quick

expert salesmanship and realism about prices, there should generally be a small profit; and small profits at the beginning of the rotation were invaluable.

Mr. Gerald Palmer said that he had been asked to say something of the Watson Report and he hoped to provoke others such as Professor Steven, Major Bowser, and Messrs. Hiley and Maxwell-Macdonald to speak. The report was the best statement of the private owners' case that had yet appeared. Its terms of reference were limited to proposing measures within the home timber industry and precluded proposals relating to such things as levy-subsidies. He did not consider this a bad thing. Security for the future would not spring from committees, grants, subsidies, or import controls. Real security for the future would come from a genuine demand for the produce from existing, new, and expanded industries and other consumers. The proposed Central Consultative Body should certainly be established if it could achieve even some of the objectives proposed for it, but he was doubtful about the use of the proposed Woodland Owners' Association. Replying later to another speaker, Mr. Palmer expanded his views on the Woodland Owners' Association somewhat as follows. Had they wanted an association of this sort, they could have formed one years ago. They did not need to be given permission for such a project. It was not so much a matter of cost as of economical use of skilled manpower. Private forestry was going ahead just as fast as was possible in view of the shortage of skilled advice and supervision. Skilled personnel was limited and they did not want a disproportionate amount of it used up in staffing the proposed Association, on an unnecessary scale or elaboration. He considered there were two practical needs which must be met and which did not depend on the formation of an Association. These were (i) an expert salesman in each area to help with marketing and (ii) much more important, the establishment of industries which would have a genuine demand for what they were producing. On the matter of the expert salesman, he welcomed the information which Mr. Barrington had just given the meeting that an expert salesman, available for the use of private owners, was attached to the staff of every Conservancy. This should be more widely known. As to competition from the Forestry Commission, it appeared to be the case in relation to the new board mills or pulp mills being established—and we had had that day an assurance from Mr. Sangar in respect of the agreement with Celotex—that the Forestry Commission had the private owners' case very much at heart and was anxious to safeguard it. The big volume output by the Forestry Commission therefore, far from being a threat to the private owner should be a safeguard to him, provided the Commission's attitude towards private owners conformed to this pattern. The principal objective must be to create these new home markets since no organization or association, or levy-subsidy or other device could be an adequate substitute for them.

Mr. Chard who followed, returned mainly to the marketing of small produce and condemned Mr. Penistan's attitude as defeatist. A real salesman could create markets and small profits could be made by good salesmanship as shown that day at Brandon. Every forester was not a salesman but, if he were not, he should employ one. He agreed later in the debate that the disposal of produce at Brandon to Celotex was at a very small margin of profit, but a new demand had been fostered and this was sounder policy in the long run than sending small pit-props north for more money. Tidiness in the wood was important on account of the danger of fire. It did not add to cost but was a matter of habit like folding one's pyjamas on getting up.

When the discussion was resumed after dinner, Mr. Hiley submitted that marketing was not at all easy in areas remote from markets. In Devon, pit-props could be sold but only down to 3½-inch tops. At Dartington, like most other private estates, all money spent had to be earned and there were a host of things such as roads and equipment to be paid for. As recently mentioned in a paper by Andrew Watt, progressive reduction in the use of timber

Mr. Morley Penistan has kindly supplied the following brief note about Weasenham.

'The New Plantation at Weasenham afforded a wonderful opportunity to study one of the least regular woodlands in Britain. Despite exposure and the reputation of the soil, very satisfactory forest conditions have been built up over the last seventy years. There are small stands with fine stems, particularly of Douglas fir (*Pseudotsuga taxifolia*), which show the excellent form associated with growth in side shade; straightness, fine branches, some natural pruning and, as a result of selective improvement fellings, long crowns. These are admirable. Others, where larch (*Larix*), albeit too limited in crown development to make fine timber trees, has been under-planted, had excellent *Thuya plicata* and *Chamaecyparis lawsoniana* saplings below and among Douglas fir poles. Elsewhere the good form of widely spaced specimen trees in side shade shows the advantages of planting in forest conditions. It is not a perfect example of irregularity; the oldest Scots pine is very rough, and now it is overtopped by younger firs it would seem reasonable to remove it and some of the rough early free grown Douglas; the middle-aged larch and pine has become short crowned and unable to respond to new growing space, while the larch planting in clearings is far too dense and will retard the advantageous ad-mixture of natural seedlings of tolerant trees. The lack of figures of size class distribution and growing stock is regrettable in this most valuable woodland. Quick counts showed the stocking to be far from normal—66 square feet hoppus per acre basal area, with a volume of some 1,600 cubic feet hoppus per acre. In spite of the dismal weather, however, to visit and admire this monument to the great skill of Major Coke's father and to his continuing management, was a memorable experience.'

III. DISCUSSION

The debate was arranged to enable both the marketing of small thinnings and the Watson Report on Marketing of Woodland Produce to be discussed.

Mr. Penistan opened on a deliberately controversial note. He considered the case for working up markets to take small early thinnings was not a very good one. A great deal of labour was needed to prepare a very low-quality product, with a high proportion of bark on bad propertied juvenile timber. At Brandon, for instance, a large percentage of the produce sold at a price which could leave little margin for profit. As it was unreasonable to strive after high prices for low-quality timber, it would often be better to leave it in the wood. It had little effect on the growth of the best stems, and wherever possible should be allowed to grow on by making crown thinnings, provided that it did not affect the wood's final health adversely. This was appreciated in many parts of the world where plantation conifers were managed, for example in Queensland where the worst poles were cut and left lying at 3 years to allow the crop to pass quickly into utilizable size and spacing widened as soon as elite stock was available. If, however, such produce must be marketed the solution was to offer large amounts to attract special industries.

Mr. Rouse hardly accepted the above view but confined his attention mainly to two points relating to small estates. Firstly, markets for their small produce had not increased and such markets as there were required expert salesmen to open them up. Small estates should join together and share a first-class man. The first thing that this salesman would want to know would be what kinds and amounts of small produce were likely to become available and he would want this information well ahead. The estates participating would therefore require thinning plans, felling plans, and planting plans, in other words, proper plans of management. Sales could then be arranged well ahead. Secondly, it was no good holding out for higher prices than this small inferior timber was worth. Given quick

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in the mines was certain and it seemed hardly likely that there would be sufficient small material in some of the more remote areas to justify the establishment of board or pulp mills. Where extraction was especially difficult, we required a modified silviculture which would reduce the need to thin; for instance, in oak coppice we might plant in widely spaced lanes only and leave the oak to clean the planted crop.

Mr. Ballance gave instances to show that good salesmanship could turn a loss into a profit. Every effort should be made to sell profitably the small early produce from plantations for two reasons. The capital cost of new plantations mounts up at compound interest and any early returns that could be got were of great value. The removal of thinnings was moreover an operation of forest hygiene.

Major Bowser said that the Forestry Commission had no right or desire as trustees to let material go to waste. They had their duty to the taxpayer to consider. We had much to learn from the French and the Germans about the disposal of small produce. Like them we must go out and seek markets and not just 'accept the inevitable'. We must apply all scientific and industrial methods. He was abundantly satisfied that the Forestry Commission in disposing of its own produce was acutely concerned at the same time with the disposal of the produce of the private woodland owners, and he was glad to hear that Mr. Palmer appreciated this. Such should be the relationship between the two interests. He had given evidence before the Watson Committee as a member of the United Kingdom Forestry Committee and was promptly made a Forestry Commissioner! This fact made his position in the debate a little difficult. He was, however, able to affirm that the Forestry Commissioners had all along the desire to further the ends of the private woodland owner. He did not agree with Mr. Palmer's view that the Woodland Owners Association would be useless. He saw in this a perfect charter for representing the precise needs of owners to government. Owners had the chance of a lifetime to force government to listen to what they had to say. He was concerned that, as seemed to be suggested, private woodland owners should be content to forward their wants through the representatives of the Forestry Commission. The U.K. Committee was of value but it was not solely a body of woodland owners. Until private woodland owners set up such a body, they could not negotiate from strength. He had heard it said that the organization would be expensive. It need not be. He felt that any necessary subscription to it would be amply repaid in better returns, and would represent very little per cubic foot of produce sold.

Mr. MacIver considered that particular areas such as inaccessible areas presented problems of management which could only properly be tackled by a completer organization than we had at present. He had in mind modifications in planting technique, modifications in selling organization, and greater attention to the economics of utilization particularly in remote areas and to the potentialities of the small man. We might then be able to sell in areas where we could not at present.

Mr. MacGregor said that the marketing problems of forestry were now at the stage which agriculture faced a generation ago. Three main methods were then involved: marketing boards, import restrictions, and independent commodity commissions. Many of these developments had lessons for forestry marketing and the Commodity Commission had much to recommend it as an administrative model. The Watson report was a good diagnosis of the marketing problem but it had many limitations and it was desirable to study the controversies which it had raised. Some of the more important of these were: (i) that the terms of reference were too narrowly interpreted when imports were excluded; (ii) the Committee were too evasive when they used the lack of financial evidence as an excuse for not making any positive recommendations about price support; (iii) forestry compared badly with agriculture in the amount of State assistance; (iv) more should have

been done to improve the confidence especially of the small woodland owner; (v) there were already too many bodies connected with forestry; (vi) the organization of a body without any power would fall on the owners themselves; and (vii) no actual marketing machinery was suggested.

If the forestry policy meant what it implied about having one-third of supplies eventually coming from home resources then the present output would have to be increased five times, or, if pulp were included, by eight times. Even in spite of G.A.T.T. and the prospect of the European Common Market some scaling down of imports might be necessary if home producers were not to be misled. A Woodland Owners Association should strengthen the power to bargain. Too much may have been made of the constitutional position of the Forestry Commission for, if it had faith in organized marketing, it need not fear a small loss in sovereignty in throwing in its lot with the private grower.

Mr. Bruce Urquhart said the Watson Report might lead people to place greater faith in forest co-operatives. In his experience co-operatives were most beneficial where fully supported by all growers in a district. There should be unified marketing of all woodland produce in each region whether Forestry Commission or private forest, by one agent. In this way it would be possible to encourage new markets, and ensure participation by all growers in a Woodland Owners Association. Pilot schemes of this kind should be started in suitable areas. Too often at present woodland owners called in a co-operative society only for the impossible tasks.

Mr. Joslin thought that at present the private owner and the Forestry Commission were tending to cut each other's throats and there was room for an organization which would stop this. On the one hand, private owners often sold timber at prices below the market value due to restrictions on periods for felling, extracting, &c. On the other hand, the Forestry Commission could do more by encouraging the trade with guarantees, for example at Thetford the local trade should be given a portion of the 'cake' to establish them. They would then also buy from the private owner.

Mr. Riddoch agreed that the Scottish problem differed from the English one. In England there were some good markets, for example in the Thetford district, where small fir pit-wood, if sold as creosoted stakes, fetched 10*s.* per cubic foot as against about 5*s.* 6*d.* if sold as pit-wood. In Scotland such fir stakes had to meet the competition of small larch which could be sold at lower prices. Scotland depended principally on the mining timber market which was most valuable because the National Coal Board, by control of imports, ensured the sale of all suitable home-grown timber. Mr. Riddoch believed this steady market enabled Scottish timber merchants to pay growers higher prices on the average than were paid in England. Scots pine, under pit-wood size, was more or less unsaleable in Scotland and he agreed with Mr. Penistan that it should often be left in the wood. This might make a wood appear to be untidy, but he agreed with the forester who mentioned that he did not like to see his woods 'cleaned, swept, and garnished'. With regard to the price of standing timber, he felt that it was always easier to buy from a seller who knew his job. Co-operative societies could help in this by providing information and advice based on knowledge and experience.

Mr. J. A. B. Macdonald supported Mr. Penistan's point about leaving small trees in the wood which were doing the wood no harm and, given room, would develop into larger trees. He was surprised to find that the views on forest hygiene which prevailed in the district were those of 50 years ago.

Mr. Harker agreed with a previous speaker that the best sales were got when the forester knew precisely what he was selling. The best policy was to work up all good local contacts, and in this respect local craftsmen skilled in the handling of minor produce were of course

invaluable. Only after that should the balance go to big concerns such as pulp or board mills. If there was to be a proper understanding between the trade and the producer, material must be properly graded to a certain standard. The purchaser must take the trouble to acquaint himself with all the facts relating to the parcel offered particularly as regards extraction. The price might reflect difficulties of access, but in the long run both parties would be saved a deal of trouble.

Mr. Rendle made the point that wood obtained from thinnings was of inferior quality in almost every way except that it was readily impregnated with preservatives. Properly creosoted round or half-round posts, &c., from thinnings were often better than similar lines sawn from mature trees. Thinnings were not saw logs and would yield only low-quality lumber, good enough for low-grade boxes, &c., but not for house-building. The thinnings house was an interesting experiment but it could not be expected to give such good service as a similar house constructed of normal building-grade lumber and this method of using thinnings was not a good advertisement for timber houses. On policy generally, the world trend was towards pulp and pulp products and this might well furnish the final answer in 40 to 50 years time. In the meantime, we should aim to produce general utility timber and not timber for special purposes.

Professor Steven said that he was surprised to find pessimism over the long-term outlook for the utilization of timber in Britain. The present proportion between small and large-size timber coming on the market was abnormal. In time there would be a larger proportion of large timber and, when new sawmills were erected for it, it would be practicable to add pulping units to use the waste and supplement the latter with small-sized material. The problem of distance might be partly solved by transporting chips and not saw timber to such pulping units as was now being done in North America and elsewhere. It was true, however, that there were immediate difficulties in utilization and marketing, due partly to this lack of balance due to the large-scale felling in the last two wars. The Watson Committee listened to all kinds of people and its report, therefore, does not reflect the views of only one sector of the timber industry. It is unique in this country in that unlike the nationalized coal and railway industries, there is both a publicly and a privately owned sector. This had both advantages and disadvantages. There may be little merit in private ownership, but there is in private enterprise. The Watson Committee has been criticized for not having provided a panacea. The problems, however, are not only immediate but continuing during the period of the development and integration of all aspects of the timber industry, hence the emphasis on a permanent form of organization which would deal with problems as they arise. The Committee felt strongly that the proposed Woodland Owners Association and the Central Committee together would provide the solution and Professor Steven believed that the cost of the former to private owners would be repaid a thousandfold.

In closing the debate from the chair, the President, Mr. Long, said that the case for finding markets for small thinnings remained the need to recover early some of the money spent. Selling at a profit depended partly on the quantities offered and this suggested closer co-operation between growers. Both the growers and the timber trade were entitled to a profit and closer partnership between them would help both. As regards the use of small thinnings for house building, he would note that the Zuckerman report (Forestry, Agriculture and Marginal Land) stressed the demand for mechanical plants to increase the utilization of small material for fabrication. He agreed with Professor Steven that the difficulties were temporary, and that the complications of the future called for more than the efforts of individuals. The two main proposals of the Watson Report should have the support of all concerned in the business of forestry.

FIG. 1

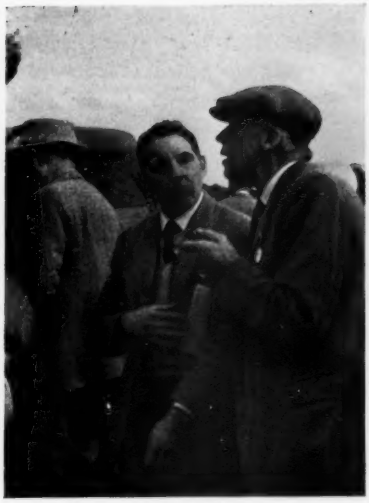

FIG. 2

FIG. 3

FIG. 4

The Society in East Anglia. Among those seen are Mr. Wynne-Jones with the President (Fig. 1); Mr. Hiley (Figs. 2 and 3) and Messrs. Chard and Riddoch (Fig. 4). The photographs were taken by Miss Mary Wellesley

PLATE IX

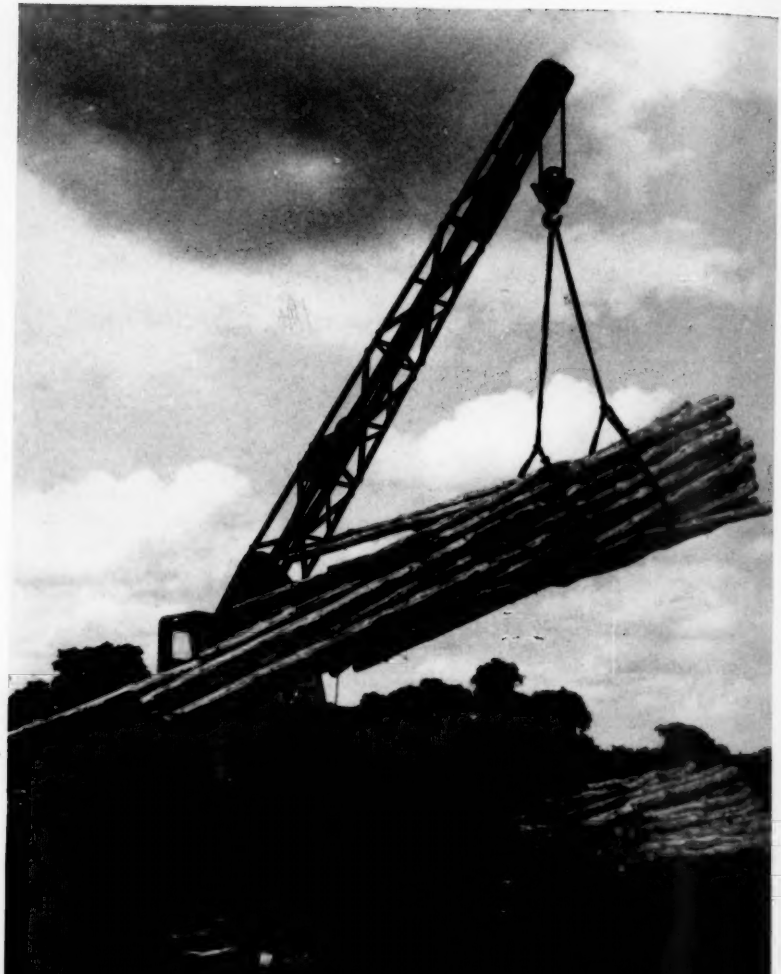

FIG. 5. The Society in East Anglia. Brandon Central Depot. Unloading peeled poles with a 3-ton crane

PLATE X

REVIEWS

Shelterbelts and Microclimate. By J. M. Caborn. Forestry Commission Bulletin No. 29. H.M.S.O., London, 1957. Pp. 135. Illustrated. Price 17*s.* 6*d.*

Review by R. W. Gloyne

IT is gratifying to read at last a substantial contribution by a British worker on the climatic effects of shelter belts, which may be set against the formidable and unceasing flow of research papers on the subject from the U.S.A., Germany, Russia, Switzerland, Denmark, and Holland. For these reasons the present reviewer, at any rate, feels that the Forestry Commission is to be congratulated for resisting the temptation to omit the references to instrumentation and techniques, without which the value of any technical contribution is severely reduced.

Dr. Caborn's work is divided into three parts, viz. 'Review of Previous Literature' (pp. 1–36), 'Consideration of Research Procedure' (pp. 42–52), and 'Results of Research Undertaken' (pp. 59–130): a bibliography of over 200 references and a short glossary complete the work. There is no index, but the division of sections, subsections, &c., is such as to facilitate reference to any topic. The analysis of the literature reviews most of the papers more or less familiar to students of the subject and gives pride of place to the work of the Swiss forester W. Nägeli. Some important Japanese papers are not mentioned—possibly because they deal in the main with the smaller type of wind-break appropriate to horticulture. The extensive wind-tunnel and field data are presented in some seven tables and fifty graphs, and in addition there is a series of useful photographs from which the reader can obtain a direct visual impression of the actual shelter belts whose wind-breaking efficiency was investigated. The work described was undertaken by a member of the Department of Forestry (University of Edinburgh)—supported by a Forestry Commission grant—and had as its major object that of devising techniques for assessing the wind-breaking efficiency of a shelter belt of a given structure from a knowledge of its geometry (i.e. its height, cross-wind length, width or depth, and permeability) assisted as necessary by a minimum of on-site field measurements.

A feature of the work is a full account of wind-tunnel studies on models of various widths, canopy profiles, and permeability. Dr. Caborn is fully aware of the need for great caution in 'scaling-up' results from models to field conditions, but he finds encouraging parallelism between the *comparative behaviour* of a group of models on the one hand, and the *comparative behaviour* of the full-scale analogues on the other. These lead him (in chapter 11) to certain practical conclusions, in which particular attention is paid to the optimum permeability for a shelter belt. Advice is given on simple field techniques for assessing the efficiency of any existing belt in chapter 11, and this chapter and the two following ones are doubtless those to which the practical man will first turn.

In the wind-tunnel work, models of various shelter-belt designs were constructed by disposing rows of nails points upwards. The main interests centred on the effect of varying the width, i.e. the downward dimension of the 'belt' from $1h$ to $15h$ where h is the height of the shelter element, and of varying the slopes of the windward and leeward margins of the system. From the results obtained from these experiments Caborn concludes that:

(i) A wide belt provides less shelter than a narrow one of the same overall permeability (i.e. a wide belt 'consumes its own shelter').

(ii) A shelving windward edge effectively increases the width (i.e. provides a less 'efficient' belt).

(iii) A shelving lee margin generally results in a reduction in the 'efficiency'.

In these conclusions he joins company with most overseas investigators, and in particular with respect to (i), finds no support for some early Danish work which appeared to show that a belt which offers an extended canopy of the order of kilometres to the wind (i.e. a 'wide' belt) gives a greater degree of protection than one whose width is measured in tens or hundreds of metres. He also concludes, rather cautiously, that cumulative shelter, in any extensive sense, does not occur. In addition to measurement of wind, a few of temperature, humidity, 'cooling power' (with a Kata-thermometer) are included. Field investigations of a number of shelter belts in the Lothians of Scotland revealed the same sort of comparative behaviour as did the corresponding group of models; leading to the practical advice referred to earlier. In chapter 13 there is an account of a model and field study of a wide plantation on the Firth of Forth which permit some recommendations on the protection of forest margins against gale damage.

Looking to the future, and having in mind particularly the need for advice on the establishment of new belts in hilly country, Dr. Caborn stresses the need for more information on the details of the effect of topography on airflow from the meteorologist, and on the effects of 'climatic stress' on farm livestock from the agriculturalist. In view of the multiplicity of factors operating, he also urges that full weight be given to such reliable local knowledge as may exist.

A number of specific matters invite comment. In the first place, although the author approached the question as a forester, the prime importance of shelter *vis-à-vis* 'horticulture' should, at any rate, have been listed on p. 42: in this field progress has been rapid in recent years—partly due to the possibility of using artificial wind screens. It would have been advisable (p. 4) to follow current nomenclature and use d for the zero displacement height instead of z_0, which symbol should be reserved for the roughness coefficient. The force of the reference to N. E. Rider (p. 5) is that Rider found evidence of wind reduction at 2 metres above ground at *63 'barrier heights' downwind*. Recently the distinction has been emphasized between geometrical permeability (i.e. the ratio of the total 'hole' area to that of the vertical projection of the barrier) and the aerodynamic permeability (which involves the absolute size of the mesh element), and this is a matter which must be borne in mind in future work. It is not correct (p. 19) to attribute the smaller rise of temperature over vegetated surfaces compared with bare soil, to the greater total area (i.e. of leaf); evaporative cooling, the insulating properties of the vegetative cover, and other factors are more relevant. The discussion of the mechanism of frost formation in sheltered areas (p. 22) is a little confusing. With respect to the effect of 'cold drying' winds on livestock (p. 43), evidence is now accumulating that cold wet windy conditions present a much greater hazard.

This reviewer would have welcomed from Dr. Caborn more information on some aspects of the wind-tunnel work. The reverse flow near a model barrier, which gives rise to negative speeds as measured by a Pitot-tube assembly, implies graphs of percentage wind speed which include negative values, and which pass upwards through zero between $10h$ and $20h$ (e.g. fig. 22 on p. 65). A small cup anemometer would not, of course, give curves of that sort. Clearly the lowest point on the wind-tunnel curves does not correspond to the lowest point on curves derived from field measurements. Again the field trials were carried out with the instrument at 2 metres, i.e. at $h/5$ for a 30-foot belt—hence the corresponding wind-tunnel results are presumably those for $z = 0{\cdot}2$: but the contrast between the wind-tunnel and field results due to a combination of different instruments, of absolute scale, of

differing up-wind roughnesses and boundary layer complication is such that a more extended discussion on the interpretation of the graphs would have been helpful. In addition, wind-tunnel data were obtained with a steady unidirectional 'free wind'; in nature the direction varies and the wind is typically gusty, thus the flow pattern is continually building-up and collapsing—any lee eddy effect may well be more a time-mean phenomenon than a steady circulation. To raise these points which were obviously also in Dr. Caborn's mind, is not necessarily to prejudice his practical conclusions: these latter, it might be repeated, are based on the comparative behaviour of a group of models and the comparative behaviour of the full-scale analogues.

A few misprints have been noted:

p. 22, col. 1, line 23—Should 'micro' be 'macro'?

p. 26–Fig. 16, but not the marginal legends, should be rotated 90° anticlockwise.

p. 29, col. 1, line 18—For 0·3 read 0·03.

p. 49, col. 1, line 18—The formula was incorrect in the original paper. It should read:

$$100\left(1-\frac{u_0}{u}\right)$$

p. 9, col. 2, line 38—Page number of reference omitted.

On the whole this is a contribution worthy to set alongside the more substantial of the works from overseas, is reasonably comprehensive within the author's stated terms of reference but is probably rather more useful to the research worker than to the practical man. However, the virtually self-contained second half from chapter 10 onwards (pp. 84–135) gives about as much definite information on the problem of shelter in hilly country as our incomplete knowledge permits; as such it should prove profitable reading for the practical forester.

British Commonwealth Forest Terminology. Part 2—Forest Products Research, Extraction, Utilization and Trade. 1957, The Empire Forestry Association, 5½″×8½″. Pp. 230. Price 30*s*.

Review by BRYAN LATHAM

THIS publication, like its predecessor part 1, is a concise, clearly printed dictionary of forest terminology, covering as its sub-title announces Forest Products Research, Extraction, Utilization and Trade. The task commenced in 1946, when the Empire Forestry Association established a Terminology Committee under the able Chairmanship of Professor (now Sir) Harry Champion, and has been completed eleven years later by the issue of part 2; part 1 covering Silviculture, Protection, Mensuration, and Management having been published in 1953. At the commencement it had been planned to put Forest Products Research on its own into a third volume, but fortunately for the working forester whose field library is already overloaded, it was found that so many Forest Products Research terms fell naturally within the scope of either part 1 or part 2 that it was wisely decided to present the British Commonwealth Forest Terminology in two volumes.

The truly immense labour of sorting, amending, defining, and clarifying the great mass of terms and definitions in part 2 can be imagined and is well appreciated by informed circles. Many have played a part, in however humble a capacity, in fashioning the complete volume of 2,400 terms as compared with some 1,700 in part 1, the increase no doubt being due to the decision to cover also Forest Products Research terms. This vast number of collaborators has rendered the question of personal acknowledgements a difficult matter, and no doubt the writer of the Introduction was wise to exercise restraint.

This reviewer feels, however, that he may exercise a welcome privilege by drawing attention in addition to the incessant and patient labours of Mr. Blanford, immediate past Editor-Secretary of the Empire Forestry Association; Professor Sir Harry Champion of the Imperial Forestry Institute; Mr. Ford Robertson of the Commonwealth Forestry Bureau, and Mr. B. J. Rendle of the Forest Products Research Laboratory, Princes Risborough.

As indicated earlier, the decision as to what to include and what to exclude from terminology part 2 was a matter for continuous debate and much heart-searching amongst the compilers, who have done their work well. Therefore, any extra matter put forward here should be taken in the nature of suggestion rather than criticism. Under Grading Rules there are mentioned No. 1 Defect System and No. 2 Cutting System. These together with stress grading are the two main grading systems at present employed in the lumber industry. Whilst the cutting system is accurately defined, it is not correct to imply that the defect system with regard to sawn timber is only used for special purposes normally graded for the size in which it is required. The defect system in fact is in use over large territories of the British Commonwealth, for instance West and East Africa, and many other parts of the world for the grading of timber intended for normal consumption. It is well known, however, that the cutting system for grading lumber is employed almost exclusively in the hardwood trade of Canada and the U.S.A.

The terminology would in fact seem to be at its weakest with regard to grading terms. On points of detail, for instance, prime, the highest grade in various grading rules, is included, but medium is not. Perhaps, however, the term almost speaks for itself.

F.A.S., meaning first and seconds, and a very common expression in many grading rules, is not defined as such either in the body of the terminology or under abbreviations. The only meaning for F.A.S. furnished is 'free alongside ship', but for every time that this abbreviation is used for the latter purpose in trade circles, it must be used a dozen times under its grading interpretation.

The definition of common takes no note of the fact that in Canadian and American grading there are no less than three grades of common, viz. 1, 2, and 3, used for very different purposes and sold at very different prices. In fact such is the quality of logs available today that at least 75 per cent. of average lumber production goes into grades below F.A.S., and these varying common grades have been carefully constructed to take care of the varying qualities.

Sapwood from a trade point of view is tackled twice, once in its own name and subsequently under the term 'bright'. It is perhaps a pity that under neither of the headings is the term 'Sapwood no defect' defined, as this is quite a common trade description in certain types of hardwoods.

Another matter related to grading is the point that under 'pin holes' it is noted that they are caused by Ambrosia beetle, but nowhere in the terminology under 'pin holes' or any other term is there any mention of the Lyctus, which is also a cause of 'small round holes in timber' and may equally be a source of great trouble in shipments of hardwood.

The definition of waste wood in its first sentence, viz. 'Those portions of a tree or log that could be utilised but are not' is quite definite. One wonders, however, by the time the material mentioned in the following note has been deducted, what will be left to travel down the waste conveyor (which is the next term defined).

In conclusion, it should be emphasized that in spite of omissions which will strike a different note with varying classes of readers, this *British Commonwealth Forest Terminology* part 2 as with part 1 fills a real need and reflects great credit upon its patient and hard-working compilers.

Exotic Forest Trees in Great Britain. Edited by JAMES MACDONALD, R. F. WOOD, M. V. EDWARDS, and J. R. ALDHOUS. Forestry Commission Bulletin No. 30. H.M.S.O., London, 1957. Pp. 167. Illustrated. Price 17*s.* 6*d.*

Review by H. M. STEVEN

THIS publication should prove to be a best seller in forestry circles. Britain pioneered in the introduction and use of exotic trees, especially conifers, and in the not distant future they are likely to predominate in our woodlands. Exotic trees, moreover, are of interest to all foresters, even to those who lean heavily towards indigenous species.

At the Sixth Commonwealth Forestry Conference held in Canada in 1952, its Committee on Forest Management, Silviculture, and Forest Protection reviewed briefly the current experience in the use of the major exotic species in the different Commonwealth countries. It was then clear that a great deal of knowledge had accumulated since this subject had been considered in detail at the Third Conference, and the late Professor R. S. Troup had published his book in 1932 on *Exotic Forest Trees in the British Empire*, which was based on the information collected for that Conference. The Committee recommended, therefore, that a similar detailed review should be prepared by each country for the Seventh Conference to be held in Australia and New Zealand in 1957, and this recommendation was adopted by the Sixth Conference. The Forestry Commission decided that their contribution should be published as a bulletin, thus making the information available to the forestry public in this country; this decision is to be warmly welcomed.

Although there is a large literature about the use of exotic trees in Britain, and much of it is referred to in this bulletin, this is the first comprehensive review of the subject in one publication. Moreover, the time is opportune for such a review, because of the great extension in the use of exotics in this country during the past 30 years. The Bulletin is divided into three parts. Part I consists of four general chapters on the place of exotic trees in British silviculture, the climate of Great Britain, the soils, and the techniques of establishment and tending. In the first of these, there is some discussion of the stages through which an exotic passes before it comes into general use as a forest tree: the arboretum stage, the trial plot, and the small pilot plantation. Many trees introduced into this country have never passed beyond the first or at most the second stage, because they showed no promise of success. As a rule, but with a number of exceptions, only species that have reached at least the second stage are included with more than a mention in this bulletin, but even thus over one hundred conifers and about fifty broadleaved species are discussed in more or less detail. In 1947, the date of the last Census of Woodlands, exotic conifers constituted 61 per cent. of all the coniferous high forest in Britain. In area, the most important species were: Sitka spruce, 167,000 acres, mainly in Forestry Commission plantations; Norway spruce, 133,000 acres; European larch, 133,000 acres, mainly in private plantations; Japanese larch, 55,000 acres; Corsican pine, 39,000 acres, mainly in Forestry Commission plantations; and Douglas fir, 38,000 acres. Broadleaved exotics have been used only on a small scale for a number of reasons. The chapter on climate is a good general summary of available information which will be welcomed by foresters for its own merit, as well as being a good guide to foresters in other countries in assessing the performance of exotics in Britain. Incidentally, it would have been as well to have stated for the benefit of foreign readers that the absolute minimum temperatures in fig. 1 are in Fahrenheit; it is mentioned in the text.

Part II deals in detail with exotic conifers, the genera, and the species within genera, being arranged in alphabetical order. For the more important species, a great deal of up-to-date and interesting information is given, it being arranged under the following headings: common name, country of origin and provenance, historical notes, extent of planting,

climatic requirements, site requirements, establishment technique—including nursery practice, vegetative reproduction, direct sowing, planting, and spacing—tending and thinning, other silvicultural characteristics, rate of growth and yield, diseases and pests, other forms of damage, seed and seed bearing, genetics and breeding, natural regeneration, timber, and potentialities of the species in the national economy. The reader will indeed be well informed if he does not learn much that is new to him. It is almost ungenerous, therefore, to mention points that might have been included. It would, however, have been both of interest and potential value to have mentioned more examples of natural regeneration. Douglas fir regeneration in the New Forest is mentioned, but there is also some natural regeneration of Sitka spruce there, while there is an unusually large number of natural seedlings of several north-west American species at Kyloe in Northumberland, and European larch regenerates with some freedom in parts of Deeside and Speyside, other than in Tom an Uird Wood near Grantown-on-Spey which is mentioned as the most notable instance for that species. Reference is made to a fine plantation of Douglas fir at Balmoral at the unusually high altitude of 1,000 feet above sea-level, but sheltered, which unfortunately was felled at the beginning of the last war when about 60 years old. It may be worth recording here that the reviewer was told almost 40 years ago by a forester who had been one of the planters that this plantation was established under birch. Reference is made to the damage caused to *Pinus contorta* by *Evetria buoliana* in England—fortunately this moth is not present in most of Scotland. The reviewer saw one of the earliest attacks about 25 years ago in a plot at Thetford Chase when the trees were 3 to 5 feet high. It looked as if someone had gone through the plantation wielding a slasher. In spite of the catastrophic damage caused, the trees recovered in a wonderful way and now, after thinning, there is little sign of distortion.

Part III deals with exotic broadleaved trees which, as already mentioned, are much less important in British forestry than exotic conifers. Sycamore is not included as it is considered to be completely naturalized, nor is Sweet chestnut discussed. Among the species which may have some limited future importance in Britain—other than poplars—are Norway maple, *Alnus cordata* on calcareous soils—the plot at Buriton, Hampshire, is outstanding, *Nothofagus procera*, and Red oak. Amongst the birch species, *B. japonica* is not mentioned; it is true that it has not yet been tried under woodland conditions but its growth in arboreta is promising. Although not important in this country, the eucalypts are given a good deal of attention, because the genus provides so many valuable exotics elsewhere. Over seventy species are mentioned, but in many instances only their death is recorded. Now that a hardwood pulp-mill is being set up in south-west England, perhaps there may be a desire to experiment further with eucalypts in that region, in view of the increasing importance of the genus as a source of pulpwood in Australia and South Africa.

The publication is well written, the production is good, and it is illustrated by a number of interesting photographs. All concerned are to be warmly congratulated on this excellent piece of work.

Quantitative Plant Ecology. By P. GREIG-SMITH. Butterworths Scientific Publications, 4 & 5 Bell Yard, London, W.C. 2, 1957, pp. 198. Price 30*s*., by post 1*s*. 6*d*. extra. American edition by Academic Press Inc., 111, Fifth Avenue, New York 3. Price $6.

Review by ALEX. S. WATT

PLANT ecology was born too early to receive at birth a handling of its data by the methods of statistics, but not too late and too deeply entrenched, like systematic botany,

to be resistant to its advances. But progress in its study has shown the need for assessments which are in the categories neither of black nor white but in some shade of grey, and for the replacement in many problems of the subjective estimate by some more objective approach, and for an expression of them in terms of probability.

Methods of estimating the contributions made by different species to the plant community form the subject matter of chapter 1—frequency, density, cover, yield, spatial distribution and its expression. As it is impossible within a reasonable time to obtain quantitative estimates of these in a stand of average area, samples are used and chapter 2 deals with 'the positioning and number of samples used'. Many techniques have been devised on the assumption that the individuals of a species are distributed at random; but many are not, showing departures from randomicity. Methods of detecting and analysing pattern are described in chapter 3. The account of methods for the assessment of the community in quantitative terms is rounded off in chapter 4 with association between species and their pattern. The other three chapters of the book cover the quantitative expression of the relationships between the plant community and environmental factors, the characterization of plant communities in terms of floristic composition, the contributions of the several components, their growth and life-form, &c., and the discussion of the nature of vegetation and whether it is amenable to classification or not.

Thus the book concerns the application of statistical methods to the quantitative estimates of whole communities, their stands, and their components. It assumes a good knowledge of statistics (a subject now dealt with in several useful texts) and a knowledge of the plant community both as a phenomenon to be described and to be understood in its morphological and functional aspects.

The author has performed a very useful service in bringing together and critically examining various methods of describing the plant community. The study of its nature is extremely complex but it would have helped in his task of assessing the possibilities and limitations of the statistical approach if he had said something more about the nature of the material he is dealing with. To treat the individual of a species as an object or counter to be equated with every other individual, whether in the form of a seedling or mature plant when their ecological requirements may be different, emphasizes the need in all such approaches not to forget the plant. The forester is fortunate in his material, so readily assessable in terms of diameter, basal area, or height: the ordinary herb or grass is less amenable, but in recognizing classes of age (or size) the forester has something to teach the plant ecologist.

Statistics is an aid in description and analysis, and it is not the fault of the method if the unwary fall into the numerous pitfalls. The author of this book is fully aware of these and warns his readers, 'mere correlation between the two variables is no proof of causal relationship either direct or indirect' (p. 99). Perhaps the reviewer imagines ambiguities where none exist. Yet the use of the verb 'depressed' would seem a trifle unfortunate in the sentence on p. 94, 'the indication is thus confirmed that the cover of *Festuca ovina* is depressed where that of *Cirsium acaule* is greater', where an active meaning may be read into it, and 'lower' is all that is implied. And the continuation 'as indeed might be expected from the morphology of the latter' is a statement of fact circumscribed by the conditions, and does not refer to competition between *Festuca* and *Cirsium* in general.

Within the limits mentioned already, the author has carried out his task well in a book relatively free from the jargon that seems indissolubly associated with statistics and plant ecology! It is well illustrated by appropriate diagrams and free from misprints, but on p. 120 'no two standards' should read 'no two stands'.

Forest Fertilization: A bibliography, with abstracts, on the use of fertilizers and soil amendments in forestry. Compiled by D. P. White and A. L. Leaf. World Forestry Series Bulletin No. 2. State University College of Forestry at Syracuse University, Syracuse N.Y. 1957.

Review by L. Leyton

IT has long been appreciated that the yield of many forest stands is limited by mineral deficiencies in the soil and that such conditions can be ameliorated and yield thereby increased by appropriate soil amendments. For almost a century, beginning largely in Germany, but now spread to many countries, forest soil amelioration experiments have been carried out, often with encouraging results. Whether fertilization or comparable measures, on a scale appropriate to the management of large forest areas is economically worthwhile or even desirable has, however, been somewhat of a controversial issue. Outside the nursery, in which intensive management is usually justified, there has generally been little enthusiasm on the part of the practising forester for soil amendments, although with the increasing awareness of advantages to be gained by such intensive measures, the situation now appears to be changing. As far as fertilization is concerned lack of interest has been undoubtedly influenced not only by economic considerations but also by the widespread assumption that forest trees make little nutritional demands on the site, at least compared with agricultural or horticultural crops. These criticisms, however, are not necessarily valid. Although it is true that the annual litter fall makes up for a substantial proportion of the annual nutrient requirements of the trees (provided of course that this litter is suitably broken down and the nutrients released in an available form) it must also be appreciated that as the stand matures, an increasing proportion of these nutrients is locked up permanently in the stems, branches, and roots and not all soils are capable of maintaining the required supply. Furthermore, whilst it can be argued that in nature, all nutrients are eventually returned into circulation, in practice, even the removal of stems only means a not insignificant loss of nutrients from the site, which, on a poor site subjected to continued cropping, may lead to serious degradation. This lesson has been well learned in agriculture but few fears would appear to have been expressed by foresters, possibly because of the very different time factor involved. The common practice of burning lop and top after cutting, thus aggravating leaching of nutrients from the site, will tend to make the situation still worse. As far as economics are concerned there is little doubt that on very infertile sites such as the *Scirpus* peats of Britain, the application of a phosphatic fertilizer at the time of planting has meant, for certain species, the difference between complete failure and successful establishment; on certain worn-out old agricultural fields of the United States fertilization would again appear to be essential for reasonable timber production. It has even been suggested that to maintain supplies, it may prove economically sound to invest money in the amelioration of poor sites with easy access to permanent roads. In his admirable introduction to the bibliography, Professor S. O. Heiberg also points out that the uncertain responses to fertilization in the few trials which have been made on middle-aged or older stands (in contrast to the numerous trials on younger stock) may be attributed among other things to the common lack of appreciation that assessment by basal area alone is a poor means of site evaluation.

Although it may be a long time before the practising forester can be induced to consider soil amelioration as a silvicultural necessity there is little doubt that today sees a rapidly increasing interest in all aspects of forest nutrition and the publication of this bibliography, covering so much of the field as it does, is therefore particularly welcome. An added advantage is that it is the first really comprehensive survey of this kind to be published in English.

In their preface, the authors state that in the selection of material, first preference was given to those investigations covering the use of fertilizers or nutrient containing materials to improve growth or affect site amelioration in forest stands and plantations. Besides inorganic fertilizers they have included organic amendments such as green manures and composts and also industrial wastes. At the same time, however, reference has also been made to articles dealing with the use of fertilizers in the nursery, with 'shade tree' and landscape practice (where these reveal an overlap of interest) and even with certain more fundamental investigations in pot trials and in the greenhouse. The extent of the coverage is illustrated by the fact that no fewer than 700 references are quoted, covering 200 journals from 30 countries. Over 50 per cent. of these references are of post-war origin, and less than 10 per cent. pre-1935; though this may be partly a reflection of degree of coverage, the figures reveal how much interest has been shown in this field in recent years.

For a work of this magnitude, obviously prepared with considerable care and attention to accuracy, detailed criticism would be presumptuous and in actuality, hardly justified. In the majority of cases short abstracts are given and where possible these have been transcribed from the original; this is indeed a very attractive feature of the bibliography and it is a pity that the remaining references, especially those of more obscure origin, could not have been treated likewise. In the index, references are classified according to the nature of the nutrient or amendment concerned with separate lists for reviews, nursery soil management and 'shade trees', its utility might have been considerably enhanced by a classification according to species.

The bibliography represents a very valuable contribution to forestry literature and will no doubt find its way on to the shelves of all those interested in the nutrition of the forest: it is to be hoped that those who still remain cautious as to practical applications will at least be stimulated and encouraged by the work which has already been done. To quote once more from Professor Heiberg's introduction, 'In spite of all the research that has been carried out in forest fertilization, as evidenced by this bibliography, there is still an open field ahead.'

Provisional Yield Table for Western Hemlock in Great Britain. By W. R. Evans and J. M. Christie. Forestry Commission Record No. 33. London, H.M.S.O., 1957. Pp. 18. Price 1*s.* 9*d.* net.

Review by W. E. Hiley

THE addition of western hemlock (*Tsuga heterophylla* Sarg.) to the list of conifers for which British yield tables have been prepared is a notable event. This tree may in future be grown much more extensively than at present, mainly because it is a rapid volume producer, and we need to know all we can about its rate of growth.

The yield table has been calculated from the results of 32 measured plots of which 20 are permanent plots, although only 17 have been measured more than once. It is found that they fall into four quality classes of which the average top heights at 50 years are 100, 90, 80, and 70 feet respectively. Nine of the plots fall into quality class I (one of these is super-first quality), eleven, nine, and three into quality classes II, III, and IV, so there is a heavy preponderance in the higher quality classes, and it is suggested that, as this is a comparatively rare species, it has been planted mainly on the better sites. There is a strong correlation between rainfall and rate of growth and eight out of the fourteen plots which enjoy a rainfall of 40 inches or more belong to the 1st quality class.

For some unexplained reason the table is not presented in the form which we are accustomed to work with. All that is given is a height growth graph for the four quality

classes and one table which relates the data normally given in a yield table to the top heights of stands. This kind of table has been called a 'master yield table' and a table for each quality class can be worked out by listing the top heights from the graph and filling in appropriate figures from the table. This is, indeed, how the 'Revised Yield Tables' were calculated.

In order to use the new yield table for western hemlock I shall need a table for each quality class. For this purpose each column in the master yield table must be graphed, suitable thinning periods must be inserted, and volumes of thinnings must be worked out. When these tables have been prepared they must be neatly typed and stuck into the Forest Record. Surely this is work which the authors of the Record might have done for us!

The table shows that at a top height of 90 feet the total volume production of western hemlock is considerably higher than that of Douglas fir or Sitka spruce at this height. Whether hemlock will produce a greater volume in a given time than these other species when grown on similar sites depends on their relative rates of height growth. My guess is that, at any rate where the rainfall is sufficiently high, hemlock is a bigger volume producer than Douglas, but may be inferior to Sitka.

The Record includes measurements of the sample plots from which the figures have been computed and this adds greatly to its value; any student who wants an exercise in the construction of yield tables can calculate his own tables from these figures. Apart from the lapse which I have mentioned the Record is a nice and informative piece of work and we are very much indebted to the authors for producing it.

Site Degradation in Stands of Natural Pine in Scotland. By D. C. Malcolm. Bulletin No. 4 of the Forestry Department, University of Edinburgh, 1957. Pp. 39 and 6 photographs. Price 7*s*.

Review by G. W. Dimbleby

THE remnants of the Scots pine forests in Scotland are of great ecological interest, not only as indicators of the past but, to the forester, as a challenge to the future. As the author of this Bulletin observes in his Introduction, work on them has hitherto been rather perfunctory, and it has particularly neglected the western variants upon which he concentrates in this paper. This study has been made primarily by field observations, supported by simple laboratory techniques on the soils, but since it was carried out as a requirement for the Honours degree in Forestry at Edinburgh, it must not be judged as if it were a long-term project. Even so, by any standards, it must be one of the most valuable pieces of work in this field and one which gives the reader a fresh picture of the ecology of these woods. The Bulletin as published is a condensation of a more detailed thesis and from it are excluded most of the observational details of the work. Whilst this may make for easier reading and certainly cheaper publication costs, it has its drawbacks. Even though the actual results are all available in Edinburgh for those who care to consult them, the serious reader finds himself considerably handicapped. Here and there it was difficult to tell whether what was said was merely the author's own opinion or whether it was fact arising from his work, but I am not going to lay the blame for this entirely at his door; one cannot always make things clear when restricted for space. As a particular instance, I should like to know whether his statements about the effect of fire in creating impedance at the surface of the soil are supported by original data.

To return to the scope of the paper: the present state of the forests is described, bringing out strongly the significance of the mound and hollow topography as a factor affecting tree distribution. This is followed by an account of the degradation sequence of the vegetation,

which is then related to the soil differences. The factors affecting degradation, particularly anthropogenic influences, are discussed in more detail together with a section on the beneficial effects of other species, especially birch. There is a disappointingly short chapter on the evidence for former forest cover in the region; in this the rejection of pollen analysis as an aid is understandable, but I think mistaken. The work concludes with a consideration of the practical implications.

It would have been interesting to hear Mr. Malcolm's view on the ecological status of these forest remnants in relation to the supposed climax but on this he remains silent; I notice, however, that he accepts the heath and moor sites without question as paraclimatic. Another point I looked for was the effect of windthrow in causing soil disturbance and thereby favouring regeneration, but as severe gales are apparently rare, possibly these woods do not show the effect as some of the eastern ones do. The adverse effect of *Calluna* on regeneration was not stressed, though other undesirable properties were firmly pinned on to it.

It would be ungenerous to criticize the various techniques used, since they were chosen for simplicity rather than accuracy, a decision which I fully support in this type of work. But the interpretation of pH readings was sometimes unrealistic; a change of 0·1 unit in spot readings cannot be held to have much significance. On botanical nomenclature I envied Mr. Malcolm his adherence to the old-fashioned *Aira* and *Scirpus* (both caespitose) whilst the rest of us have to use the less euphonious *Deschampsia* and *Trichophorum*.

Never having seen any of the four woods studied, the Black Wood of Rannoch, Doire Darach, Crannach, and Auchreoch, some of my previous impressions are shown to be faulty, but I feel both informed by Mr. Malcolm's descriptions and convinced by his arguments, even though some queries still remain about details. This paper is of interest to students at all levels, not only in forestry but in the wider field of ecology.

New Ways of Using the General Tariff Tables for Conifers. By H. D. S. Finch. Forestry Commission Record No. 32. London, H.M.S.O., 1957. Pp. 11. Price 1*s.* 3*d.* net.

Review by R. Lehtpere

SOME years ago the Forestry Commission began the study of the relationship between volume and basal area. Following this work volume tables for various species and Tariff Tables for Conifers—Forest Record No. 31—have been published. The mathematical background of these publications can be found in Bulletin No. 24 entitled 'The Volume–Basal Area Line', which was reviewed by Professor H. M. Steven in *Forestry*, xxix. 71.

By means of the Forestry Commission Tariff Tables it is possible to calculate the stand volume or the volume of marked thinnings if we know the mean tariff number and the number of trees by girth classes. The tariff tables are arranged according to tariff numbers, which are modified regression coefficients of the regression of volume on basal area with the volume line intercepting the X-axis (basal area) at 0·03 sq. h. ft.

Mr. Finch's work deals with the determination of the mean tariff number, and his investigation is based on Forestry Commission sample plot data. Firstly he studies the mean tariff numbers of thinnings and the difference between the mean tariff numbers of thinnings and the main crop sample trees. His main statements can be summarized as follows.

1. The mean tariff numbers of twenty thinnings of largest girth do not differ significantly from a random sample of all thinnings. This is valid for the eight main conifer species and for the usual Forestry Commission thinning grades.

2. When all thinning grades were analysed together, then, out of ten main species, only Corsican pine and Douglas fir showed significant differences between the mean tariff of the thinnings and the mean tariff of the main crop sample trees. But when the B grade plots were excluded from the data, only Douglas fir retained significance.

3. When the data were grouped by thinning grades there was a significant difference between the thinning tariff and the sample tree tariff of the main crop for B grade plots, and no significant difference for D or L/C grade plots.

Mr. Finch came to the conclusion that, if the mean tariff number of the main crop is estimated from the thinnings instead of from the main crop sample trees, there will be a small general under-estimation in the main crop volume for the thinning grades practised in the Forestry Commission woods. This under-estimation corresponds to about one tariff number, but the volume increment calculations are little affected.

Secondly, Mr. Finch describes how a relationship is established between the top height and the mean tariff number of the main crop. A table shows this relationship for Scots pine, Corsican pine, European larch, Japanese larch, Norway spruce, Sitka spruce, and Douglas fir for top heights from 30 feet to 79 feet. This table has been tested against recorded measurements of 323 sample plots (a systematic 25 per cent. sample), of which 276 showed errors in the volume estimate of less than 10 per cent. of the measured volumes, and the remaining plots showed an error of over 10 per cent. The total measured volume was 0·3 per cent. smaller than the volume calculated from top height/tariff number relationship.

In the first part of this study the arithmetical average of sample tree tariffs has been used for the determination of the mean tariff, which can be written

$$T_m = \left(\frac{0{\cdot}97\,V_1}{\text{b.a}_1-0{\cdot}03} + \frac{0{\cdot}97\,V_2}{\text{b.a}_2-0{\cdot}03} + \ldots + \frac{0{\cdot}97\,V_n}{\text{b.a}_n-0{\cdot}03}\right) : n,$$

where V is volume in c. ft. and b.a. basal area in sq. h. ft. of individual sample trees, n is number of the sample trees, 0·97 and 0·03 constants. A mean tariff for Forestry Commission Tariff Tables can also be calculated by formula

$$T = \frac{0{\cdot}97 \sum V}{\sum \text{b.a.} - 0{\cdot}03n}.$$

($\sum V$ = total volume and $\sum$ b.a. = total basal area of sample trees.) Usually these two tariffs differ and, according to the theory of the volume-basal area line, this is mainly due to the inconsistence of sample trees. Nevertheless, the reviewer prefers the second method because this tariff always gives the exact total volume of the sample trees, and this volume calculated by the first method can differ sometimes up to 4 per cent.

It would have been advisable if, in the thinning tariff inquiry, a number of thinnings of the smallest girth had been compared with a corresponding number of the largest thinnings. In this respect the results summarized in table no. 1 do not give enough information because part of the twenty largest thinnings appear again in the random samples.

In table no. 6, which shows tariff number against the top height, it would have been desirable if regression coefficients for each foot of height had also been given. Regression coefficients are convenient to use in the field, and the total volume of a stand can be calculated by formula

$$V = (\sum \text{b.a.} - 0{\cdot}03n) \times \text{reg. coeff.}$$

Here the total basal area can be estimated, for instance, by means of the relascope.

It can be shown mathematically that if the volume increments of two low thinning

grades calculated by the same top height/tariffs are to be equal, then the thinning grade with the smaller basal area must have the larger basal area increment. The top height/tariff may not be exact enough for this kind of problem, but it would be useful to know if there is evidence of it directly in the Forestry Commission sample plot data.

Mr. Finch's paper is an important contribution to the study of the volume-basal area line and his result holds promise of being very practicable. We hope we shall have further reports on this subject, particularly on how the top height/tariff works in the field.

Tree Care. By JOHN M. HALLER. New York and London, The Macmillan Company, London Branch, 10 South Audley Street, W. 1. 1957. Pp. viii+224 with 77 photographs and 3 diagrammatic drawings. 6″×8½″. Price in U.S.A. $5.95. Price in U.K. 41*s.* 6*d.*

Review by N. D. G. JAMES

IN this country there are very few books on the care, protection, and treatment of ornamental trees, and none, as far as I am aware, which is written specifically for the home-owner. It is, however, largely for the owner of the American home that Mr. Haller says he writes, and in doing so he has produced a very readable book.

As an introduction to the subject of tree care, the author devotes the first chapter to describing the structure and fundamental parts of a tree. Although this contains a considerable amount of information, some of it can hardly be accepted. The statement that heartwood is of more concentrated growth than sapwood, emphasized by a diagram showing the annual rings of the heartwood far closer than those of the sapwood, is, to say the least of it, misleading. The observation that 'since trees grow more in wet years than in dry years, the widest rings indicate wet years, the narrowest rings dry years' is unfortunate, since it implies that the width of the annual ring is due solely to rainfall, and it appears to overlook the other factors which affect the growth of the tree, and therefore the width of the rings.

Nevertheless this book contains much that is of interest to those who are concerned with the care and repair of specimen trees, whether they live in Britain or America. It is suggested that the best size of tree for transplanting is one '4–6 inches in diameter and 18–20 feet in height'. The lifting and moving of trees of this size is achieved through the practice of 'balling and burlapping', which the author describes and which appears to be more general in the United States than it is in this country.

In the case of the treatment of tree wounds the author considers that creosote or paints containing creosote should not be used, since he is of the opinion that this substance injures the cambium at the edge of the wound. He recommends instead what he describes as 'asphaltum mixtures' and 'pine tar', the latter being a substance used by veterinary surgeons for the treatment of flesh wounds.

Two aspects of the care of large specimen trees which are not commonly met with in this country are the application of artificial fertilizers and spraying.

A chapter on diseases, although chiefly concerned with those occurring in North America, includes accounts of Honey Fungus (*Armillaria mellea*), referred to as 'Shoe-string Root Rot', Chestnut Blight (*Endothia parasiticum*), and *Nectria* spp. The corresponding chapter on insects is less applicable to this country.

The author has included an instructive chapter on what he describes as 'Environmental Damage and Miscellaneous Troubles', which covers damage by the elements, smoke, gas, ironmongery, animals, fire, and—to be really up-to-date—atom bombs. The book concludes with a chapter on tools, equipment, and books.

It is unlikely that this book will enjoy a very wide circulation in this country, owing to the fact that the general public for whom it is primarily written are not as interested in trees as apparently the American public are, and also owing to its cost. This does not, however, detract from the value of the book, which should be helpful to anyone concerned with the repair and maintenance of specimen trees. The photographs are excellently produced, clear, and instructive.

Sapinières (*Silver Fir Stands*). *Selection Working by Area* (*Check method by Means of Curves*). By A. SCHAEFFER, A. GAZIN, and A. D'ALVERNY. Translated by M. L. ANDERSON. Bulletin No. 3. Forestry Department, University of Edinburgh, 1957. Pp. 52. Price 7*s.* 6*d.*

Review by T. E. EDWARDSON

HAD the authors in 1930 realized how widespread the interest in the method of control was to become, they might well have been tempted to relegate the parochial principal title of *Sapinières* to the sub-title and use the latter, *Selection Working by Area*, to give a more meaningful indication to a wider public of the contents of this classic of control method treatment.

Professor Anderson, in this translation of the original publication by the French foresters Schaeffer, Gazin, and d'Alverny, has perpetuated the silver fir's pride of place in the title, and, for the British forester at least, this suggests the first important point for comment—the treatments, régimes, and techniques described are considered only in their application to the true selection forest and, therefore, to species such as silver fir capable of thriving in these silvicultural conditions. Under our conditions, particularly of light intensity and weed competition, no native species of timber value has shown itself to possess the essential features for selection working of capacity to thrive in shade (survival is not enough) and the power of effective and regular natural regeneration. Any thoughts we may have then of applying directly the ideas and methods discussed in *Sapinières* must revolve around our exotics, and in particular, the second-string West American conifers such as Lawson cypress, *Tsuga heterophylla*, *Abies procera* and *grandis*, and *Thuya plicata*. With some of these there have been, of course, limited successes in uneven-aged mixture (Weasenham, Bolderwood, Kyloe, and other show places come to mind), but the main investment in potential 'selection' species is in the wet west and there the sheep, the returning rabbit, and a rampant field layer must make success in this direction, economics apart, at least uncertain.

However, the possibility of any extensive direct application of the methods of *Sapinières* was probably not in the translator's mind. One suspects that *Sapinières* is a continuation of an evangelizing process of which the translations of Knuchel's *Planning and Control* and Biolley's *Planning of Managed Forests* were earlier stages, the ultimate objective being to establish empirically (in keeping with the spirit of the method itself) what variations of the method are likely to be suited to British conditions, and to which types of British forest they can be usefully applied.

We have some continental encouragement to allow ourselves to be 'converted': Professor Kurth, Knuchel's successor at Zürich, takes pains in his writings to talk of a 'control idea' rather than a 'control method' and Professor Köstler of Münich, referring to Knuchel's book, said that a chapter on the application of the control method to even-aged forests would have aroused a great deal of interest. In fairness, however, and appositely because of the book under review, one must at the same time record the description of the method of control by the harassed French forest officer in charge of extensive areas of

even-aged forest in Western France as the 'method of the retired conservators'. This objection to the method on the score of the demands it makes on the time of supervisory staff goes back at least to the original French review of the book.

If in a British context we read for 'retired conservator' either 'interested small woodland owner with suitable species', or even, for that matter, 'retired conservator', then direct application of the lessons of *Sapinières* may be possible. For the great bulk of the extensive even-aged forests of Britain, however, when the time comes for a sufficient intensity of management, a solution to the reviewer is to make use in a process of periodic inventory of the mensurational aspects of the method of control on a sampling basis: the 1,400 acres covered by over 500 stratified sampling units in the various timber crops, age classes, soils and sites of Dean Forest's 25,000 acres, are his personal contribution to a continuing testing and modification of Gurnaud's original idea. A brief contrast of the Dean approach with that discussed in *Sapinières* may usefully suggest the value and limitations of the book for the British forester.

Historically, the main interest of *Sapinières* and its lasting contribution to the method of control is the idea of influencing the course of management and the silvicultural development by graphical comparisons, not of growing stock volumes, but of the actual frequency distribution by diameter classes with an ideal exponential (de Liocourt) type distribution. That such an attempt should have been made at ideal distribution and equilibrium within the frustrating limits of the individual compartments is a topic of present day debate, and raw material for argument is given in chapters iv and v. Tropical service members of the Society will find not only much of interest here, but also the early foundations of H. A. Meyer's later studies of structure, growth and yield in balanced uneven-aged forests (see *Forestry*, xxviii. 2).

The problems arising in the Dean are, if stimulating, also numerous and not always easy of solution. Since a static 'ideal' structure (or curve) does not exist in the even-aged stand, Schaeffer's approach does not apply and instead a knowledge of volume increment must be the goal. On the mensurational side there is the elusive, side-stepping nature of the local volume table for an even-aged stand with the passage of time, to which the Hummel tariff series offer a welcome 'off-the-peg' solution: on the statistical side there are the difficulties of choosing a sampling unit size to please both forester and statistician, the problem of effective practical stratification particularly in regard to site, the question of deciding a sampling intensity adequate to ensure an acceptable standard error of the increment rather than of the growing stock. All these troubles, at least, are avoided by the selection forester with his 100 per cent. cover and his comforting conventional, unique tariff (how far he is justified in resting on this apparently stable foundation when one realizes that even Couvet is not all selection forest is another question).

In the preface to *Sapinières* it is made clear that the intention is to concentrate on the practical considerations arising in the application of the method of control and, to this extent, provide a text complementary to Biolley's earlier classic which concerned itself with a physiological theory of selection working. Chapter i deals with the principles, chapter ii describes in detail the normal procedure, chapter iii elaborates some of the points to cover exceptional cases and possible improvements. Chapters iv and v contain the discussions of silvicultural and management-planning implications of the new methods suggested by the authors. The twelve tabular appendixes of the original have been heavily condensed in the translation.

Professor Anderson (in both title and text) has struck firmly ('grimly' would be the wrong word to use of him) to a literal translation—unfortunately almost unannotated, and occasionally leading to some confusion in the English reader's mind when, for instance, on the

subject of calling out tree diameters in the field he finds himself being advised to 'say "*neuf*" (nine) instead of 45: Zero (and not *dix* which may be confused with *six*) instead of 50'.

More valuable to this disciple and, he suspects, to other British foresters and doubtless to other English-speaking foresters would have been an original contribution from Professor Anderson (incidentally more in line with the avowed object of this series of Edinburgh Forestry School's Bulletins), following the various developments and modifications in Europe and elsewhere of the method of control, and including some discussion of his own experience, since his article in *Scottish Forestry* in 1953, with the check method at Glentress, Corrour, and elsewhere, when applied to conversion of regular to irregular forest using a wide range of species and variable group size. Has the 'hopsil' a leg left?

Tree Injuries. Their Causes and Their Prevention. By H. L. Edlin and M. Nimmo. Thames and Hudson. 1956, 6″×8″, with 125 photographs. Price 21*s.* net.

Review by T. R. Peace

TREES, like any other living organisms are liable to injury from a very large number of living and non-living agencies. Not only do all the extremes of our variable climate affect trees adversely, but they can also be damaged by animals, insects, fungi, and bacteria, as well as by man himself. It is hardly surprising therefore that the causes of tree injuries, let alone their prevention, can only be dealt with very briefly in a small volume of 165 pages. It is greatly to the credit of the authors that they have given so much valuable information in so small a compass. Where insects and fungi are concerned the book can only describe some of the principal offenders and it is therefore only of very limited value for the actual diagnosis of pests or diseases. But the chapters on 'Climate', on 'Damage by man', and on 'Damage by mammals and birds' do cover the ground more thoroughly, though the scientific basis of the information they give is naturally omitted. They should prove a valuable corrective to those who feel that all ill-health in trees must be due to active agents such as fungi or insects. These chapters on non-living agencies, together with those on 'Climbing and parasitic plants', on 'Old age', and on 'Deformities and curiosities' cover ground which has been sorely neglected in British forestry books of the present century. The photographs are nearly all well chosen to give a full coverage to the subject, and are of excellent quality.

It is a book that every forester should possess. It will not enable him to diagnose all the ills from which his trees may suffer. It will certainly not enable him to prevent such ills; for the subject of the prevention and control of forest diseases and pests is a very difficult one, which cannot be adequately dealt with in the volume under review. But it certainly will broaden his knowledge and appreciation of the many and diverse agencies which, singly or together, may be affecting the well-being of his trees, and will often suggest the direction in which he should turn for more detailed information.

Tree Root Development on Upland Heaths. By C. W. Yeatman. Forestry Commission Bulletin No. 21, 1955. H.M.S.O. Pp. 72 with 32 photographs and 29 diagrams. Price 10*s.* 6*d.* net.

Review by G. W. Dimbleby

THE first impression one gets on looking at this work is that it contains a great deal of information, not only on the subject as given in the title, but also on the natural background against which these investigations must be seen. When one realizes that it was all carried out in less than 18 months by someone hitherto unfamiliar with Britain, one is left wondering whether all Australian foresters (as Mr. Yeatman is) work at this rate.

The Bulletin is divided into six chapters dealing with: The Ecology of Upland Heaths; Methods of Investigation; Results of Studies at Allerston Forest, Yorkshire (2 chapters); Studies in North-east Scotland; and finally Conclusions. Within this framework the root systems of several coniferous species are discussed in varying detail in their relationship to soil characters, cultivation (including subsoiling), and sometimes to fertilizers. Such a programme is liable to become unbalanced since it is virtually impossible to give equal emphasis to all aspects; in fact, the field material does not allow it. Even so, one must question the author's judgement in allowing the balance at times to become unnecessarily one-sided. For instance, the section on Sitka spruce at Allerston, whilst invaluable to those concerned directly with experiments on this species, will be of less interest to others. On the other hand, the full treatment of Japanese larch, a more useful species, is particularly valuable.

Mr. Yeatman has attempted to combine basic observations on tree root systems under heath conditions with the often complex effects of a variety of cultivation types. As a result we have a rather ungainly hybrid between a description of the root systems themselves and an account of the benefits of one type of cultivation or the other. His bias is, understandably, towards the field applications, but it is to be regretted that he did not take greater note of the literature available on root systems, particularly the work of Laitakari. However, in his conclusions he brings out strongly the advantages which cultivation confers upon the developing root system and he has shown that even our so-called shallow-rooting species will go deep if they get the slightest chance, and that it benefits them to do so. In other words, shallow rooting is as much an expression of site characters as of an inherent tendency in the species, a point which should influence the type of cultivation chosen.

In the clear presentation of a complex subject such as this, diagrams should play a very important part and this work is well supplied with them. Some of those given, however, do not serve their purpose as well as they ought. The profile diagrams are on the whole excellent in conception but suffer in reproduction by the use of a weak colour (green), which is lost against a black background, to represent the root systems; consequently the distribution of roots, the very thing we want to know about, is in many cases indecipherable. The histograms, though doubtless containing all the relevant data, are too complex and variable to convey the information to the reader, and they have no legend. It needed quite a lot of research to find out why a plot was recorded as having 100 per cent. rooting below the pan when the plot descriptions mention considerable rooting in the upper layers. Diagrams are a form of communication, and if they cannot be made to convey the information they are better not used; in this case the tables were much easier to comprehend.

Nevertheless, I do not wish to strike too critical a note since there is so much of value in this work. What the forester has frequently talked about in the abstract is here in concrete form and we must be very grateful to the author for the labour he has expended in getting it. Anyone concerned with the afforestation of our upland heaths should be familiar with Mr. Yeatman's conclusions.

With so much research work going on in certain of the Forestry Commission's forests, they are not infrequently mentioned in a variety of publications. It always seems necessary, as in this Bulletin, to give full geographical, pedological, ecological, and other details as background, and even within one work this can become repetitive. Further research reports are certain to be published and I think that a publication by the Forestry Commission, specifically dealing with their research areas from this point of view, would not only remove the onus from specialists to cover this background (even though they themselves may only make incidental reference to it), but would indeed have considerable intrinsic value in itself.

Utilisation of Hazel Coppice. Forestry Commission Bulletin No. 27, London, H.M.S.O., 1956. Pp. 33 with 32 photographs. 10*s.* net.

Review by the Editor

FOR many years only a small part of the total area of hazel coppice (*Corylus avellana* L.), most of which is in southern England, has been managed on a regular rotation. Before considering the problem of expanding existing uses or finding new ones for hazel, the Forestry Commission's Advisory Committee on the Utilisation of Home-grown Timber felt it necessary first to know (*a*) the area of hazel required to meet the demands of the existing hazel underwood industry, and (*b*) the yield per acre from hazel coppice. The problem could then be examined in its true perspective. The bulletin gives the results of the investigation and research set up to ascertain (*a*) and (*b*) and also the results of work undertaken recently for the advisory committee by the Bowater United Kingdom Pulp and Paper Mills Ltd. in respect of pulp for board making; by the British Paper and Board Industry Research Association in respect of pulp for paper making; and of a practical test of paper making carried out by the Manchester College of Technology. This and other information is set down in successive chapters on (1) distribution and extent; (2) management and utilization; (3) the hazel underwood industry; (4) yield; (5) new uses; and (6) discussion and conclusions. There are 32 good photographs supplied by the Rural Industries Bureau mainly illustrating stages in the working up of hazel underwood by traditional methods.

The area under hazel given in chapter 1 includes coppice with standards, simple coppice, and scrub and is taken from the 1947–9 census of woodlands and totals 167,000 acres. Some of the coppice with oak standards, particularly where the standards are self-butted and fast growing, is already reasonably productive by reason of the standards alone and is a valuable reserve for the future of the very kind of oak most likely to be wanted and therefore most likely to produce high prices. We should be thankful for these and not worry too much about what is under them. Little will be got from the scrub. So the net area for consideration is not more than 100,000 acres. In chapters 2 and 3 the working of hazel in the traditional manner on a rotation of about nine years is discussed. Mr. Bruce Durham considers that the most important demands today are for crate rods; sheep and garden screen hurdles; pea sticks; bean sticks; thatching spars, liggers and sways; and to a lesser extent, sheep cages, hedge stakes, and hetherings. The demand for crate heads and rods for packing pottery is decreasing owing to the preference for small cardboard containers but the demand for wattle hurdles is greater than the supply. Mr. Trust discusses the results of the survey carried out by the Rural Industries Bureau to find out the existing numbers of hazel underwood cutters. Excluding hazel cut by estate employees there are about 300 full-time workers in hazel. On an average they will require 5 acres a year each so that with a rotation of 8 to 10 years the total area required is about 12,000 acres more or less. It is good to learn from Mr. Trust that some success is being achieved in getting men back into the industry and it is to be hoped that it will continue. A great deal is at stake and it cannot altogether be measured in terms of pea sticks or of crate rods but in the peace, welfare, and beauty of the English countryside as well. All the same the areas under hazel are far in excess of what can ever again be used.

The rest of the bulletin deals with the work done so far to find other uses for hazel. In chapter 4 Mr. Jeffers investigates the yield to be expected from hazel not in terms of the converted product but in weight of freshly cut hazel per acre. Specific gravity and moisture content are also considered. He finds that from well-stocked coppice the yield should be from 2 to 2½ tons per acre per annum for rotations of 10 to 20 years. Increment falls off

after about 15 years as might be expected. Chapter 5 gives an account of the tests made with hazel for hardboard and for paper. The trouble is that the material is too small and too hard to be really attractive for pulping but the reports do agree that it can be used if sufficiently moist and if mixed in with other species. There is, however, no chance of hazel being worked solely for the production of pulp or of pulp mills being set up solely for the digestion of hazel. The most that can be expected is that pulp mills will accept at a price some of the larger hazel cut during replanting operations which would otherwise be wasted.

What is not mentioned in the bulletin but which seems quite possible is that unworked hazel left for 35 years or more will be too hard and too dry to be of use as pulp and that at 50 to 60 years it may well be dying. Such hazel would be easy to clear and, as much of it is already pretty old, the solution may lie in the development of suitable machines for clearing and in modifications in planting techniques rather than in pulp markets. The reviewer is familiar only with hazel management in one part of Herefordshire but here certainly the greatest need is to hold together the remnants of the hazel cutters and to continue to work a selected fraction of the area in the traditional manner. Any area which can keep a nucleus of skilled workers however small will be in a much better position to deal with changes in management than where there is no such nucleus.

The use of Home-Grown Timber in Packaging and Materials Handling. By J. R. Aaron. Forestry Commission: Forest Record No. 35, London, H.M.S.O. 1957. Price 2*s.* 6*d.* net. Illustrated.

Review by the Editor

An account of a survey carried out between July 1954 and August 1956 to assess the extent to which home grown timber and especially sawn home-grown softwoods could be used by trades concerned with packaging and materials handling. The inquiry was not concerned with the demand for forest produce for fibre cartons nor with plywood. Altogether 238 packing case, pallet and stillage makers were interviewed and a further 27 replied to a questionnaire sent by post. The concerns visited varied from large modern plants with automatic machinery to two-men businesses using second-hand timber. The account deals separately with packing cases, horticultural boxes and crates, bottle boxes, cases for wines and spirits, fish boxes, boxes for textiles, veneer boxes, packages for pottery and glass, and lastly with pallets and stillages and much interesting additional information is given under each. To give two examples only from several. Producers of home-grown fruit and vegetables are handicapped in marketing their produce by having to use returnable boxes instead of the more convenient non-returnable ones used by importers. Chip baskets are better for packing soft fruit than fibre cartons because they are better ventilated and the fruit therefore ripens more slowly in them. Some notes then follow on the principal timbers used in the trade, both imported and home grown, and their respective advantages and disadvantages for particular uses. Whiteness for boxes which are printed as in the wine packing trade (spruces). Blue sap stain (pines). Resin and the liability to split when nailed (larches). Weakness in the cedars and sequoias (with cedars is apparently included *Thuja plicata*). Douglas fir is said to be hard on saws and to split when nailed.

All the firms visited were asked for their views about the use of home-grown timber. Many were already users and anxious to obtain more and it seems that at present about 12 per cent. of the sawn softwood used by these trades is home grown. The chief complaints made were about inadequate seasoning and inaccurate sawing particularly the inclusion of wane. There was a fair majority in favour of grading and specifically on a system of grading rules on the lines of those recently published by the Forest Products Research Laboratory

in their leaflet No. 49, but there was more general agreement that material must be supplied to a rigid specification and supplied in sizes to which the particular trade was accustomed. To give one example only. With the exception of sawn box boards, the bulk of the imported material is ordered in thicknesses of 2, 2½, or 3 inches and in widths of 4 inches and above, with an average of not less than 6 inches. The maximum width required is about 9 inches. It was frequently suggested that the home grown trade should endeavour to produce these sizes rather than supply random widths or squared logs as at present.

The record, which is well illustrated with photographs, replaces a report on a similar inquiry held in 1933 which is now out of print.

NOTICE

We publish for information the following received from the Forestry Commission and dated 6th February 1958.

Importation of Oak Trees

When the importation of living trees of the genus *Quercus* was prohibited under the Importation of Forest Trees (Prohibitions) Order 1952, it was appreciated that the growing of standard oak trees was largely a continental speciality and that few were obtainable in this country. It was also realized that there were some varieties of oak in cultivation on the Continent which were hardly in commerce here. In the circumstances, a period of five years was allowed in order to build up stocks in Great Britain, and during this period the importation of standard trees and special varieties was permitted under licence.

The risk from Chestnut blight, which can be carried on oak, is greater than it was five years ago, for it is now known to have spread to France. In view of this, and since the five years have elapsed, the complete prohibition of the importation of oak trees will be enforced as from 1st April 1958. No issues of special licences will be made after that date.